A MANAGEMENT SURVEY OF W. & L.E. GURLEY

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HISTORY

The W. & L. E. Gurley Company is one of Troy's oldest and most respected business enterprises. Pioneers in the design and production of quality surveying instruments, the Company has expanded its facilities during the years to provide for the development and production of industrial measuring instruments, high precision optical equipment and, more recently, has begun the manufacture of products requiring photo-processing techniques.

In 1947 the Company published a pamphlet entitled The Gurley Story outlining the history of the Company. Permission has been granted to reproduce the pamphlet material, portions of which appear below.

"One hundred and eight years ago in 1839, a young man graduated from R. P. I. in Troy as a Civil Engineer. He journeyed to Michigan to practice his profession, but the prospects were discouraging and so he returned to Troy. About 1840 he became an apprentice to Oscar Hanks in his small brass foundry on Elbow (now Fulton) Street and began to lay the foundation for all you see today in the Gurley plant. His name was William Gurley.

"In 1845 he formed a partnership with Jonas H. Phelps, still continuing the business of making compasses and mathematical instruments, with the casting of brass. In 1852 his brother, Lewis E., graduated from Union College in Schenectady, became William's business partner, and formed the firm of W. & L. E. Gurley.

"Although the brothers could not have known it then, the

small business they founded was to become one of the largest and most respected in the field of instrument making. Its products have served their country in three wars, and have received the highest Government award a company can earn.

"Together the two brothers set about improving the products of their plant. New ways of doing things were discovered. The Gurleys were always willing to try a new material . . . listen to new ideas, and try them.

"The Company had grown considerably when Civil War was declared in 1861 and the W. & L. E. Gurley plant became the scene of great activity. New faces were seen on the streets in Troy. More and more men worked at the machines. And from the plant flowed a steady stream of war materials . . . fuse plugs, gun sights, and shell caps. One year later, in 1862, the Great Troy Fire destroyed most of the City. The Gurley shop was burned to the ground. So were the homes of many of the workers, along with those of the two brothers. A new factory was soon built on the same site. That building, now greatly expanded, is the plant . . . today.

"In 1876 the Gurley Company made the first 'Light Mountain Transit', a model which has been popular with Engineers engaged in mining or mountain surveys for more than fifty years. Use of aluminum in making another Gurley transit made the Company the first in America to use that metal on a commercial basis. In 1885 another Gurley 'first' was the use of platinum for the cross-wires that made more accurate measurements possible. The continued plan of the Gurley brothers to try out new ideas resulted in many other improvements.

"William Gurley, the Founder of the Company, died in 1887. His brother and partner died in 1897. Both had spent their lifetimes in building a business of which Troy can be truly proud. In 1900 the management was taken over by William F. Gurley and Paul Cook, heirs of the two brothers.

"More products were added to the line. The Company began to manufacture Weights and Measures, Alidades, Paper Testing Instruments. In 1940 Textile Testing and Wind Instruments were added.

"The second World War saw Gurley instruments used in every type of climate and under all weather conditions. They had to do their work under the hot desert sun and in the icy North. In the mud of Germany and in the dust of China. Instruments built . . . in this plant . . . were shelled, dropped, watersoaked and even burned. That's why, in 1945, when the Company celebrated its 'first hundred years', the United States Government had already awarded W. & L. E. Gurley the Army-Navy 'E', with stars for continued good production."

In 1942 the Company began to manufacture instrument reticles by the process of etching, rather than with platinum wires, and by the end of the second World War all reticles were being made by this method. By 1946 the Company was also making various special reticles for other concerns and during the Korean incident many such reticles were produced under Government contract.

Since 1952 the Company has also provided special contract services for concerns interested in the development and production of items requiring photo-processing facilities and this phase of the business is growing steadily.

COMPENDIUM

In order for any company to compete favorably in an increasingly competitive business world that organization must be dynamic in the sense that problems can be detected and solved quickly. A dynamic organization should include management personnel who are constantly improving their knowledge of modern management principles to the extent that these principles can be profitably applied to the business concerned. It appears as if the Gurley Company has not retained a dynamic status and that there are some phases of the business in which improvements could be made by revising present policies and implementing other more applicable management principles.

During the course of this survey it was implied by Company personnel that many of the problems confronting Gurley resulted from the lack of a modern plant and equipment, and that these problems would automatically be solved by acquisition of new facilities. It is realized that the present facilities hamper operations considerably, but it is believed that there are other problems confronting the organization which are just as important and should be solved whether or not new facilities or rearrangement of the present plant layout is considered. The purpose of this section is to summarize the recommendations considered of prime importance.

The problems confronting the Sales Department are considered to be of great importance to the Company. The reason for this decision is that the productive output must be sold in order to realize profits and because planning and productive policies are based on sales forecasts. A good program of market research must be developed in

order to achieve accurate sales forecasts and to discover ideas for new products which could be developed. The Company must also develop an aggressive sales approach through a more thorough representation in the field and a stronger, more complete dealer system. More emphasis should be given to the development of reticle sales volume. Closer centralized coordination and more specific delineation of responsibilities is needed. Adoption of these recommendations should result in greater sales volume.

Another problem is one that should be solved regardless of whether new facilities are acquired or a rearrangement of present layout is undertaken. This problem concerns product design, methods, standards and process flow. A review of product designs should be made to ascertain whether tolerances can be relaxed and still allow proper functioning of instruments. Methods then can be established and standards set. Process flow and plant layout could follow or be accomplished in conjunction with these improvements either in new facilities or as a rearrangement of present equipment. These changes should result in more economical productive costs.

It is apparent that a need exists for better organization and delineation of duties in the Gurley Company. It would be advisable to consider organizational recommendations in conjunction with all other recommendations. The reasoning for this is that ultimate Company policies, goals and the desired organization must be decided upon before commencing implementation of recommendations. When the decision has been made to adopt certain recommendations and organization changes,

permanent position assignments can be made. Personnel so assigned should insure that adopted recommendations relative to their positions are effected. When time permits, the Industrial Relations Manager should coordinate the final smoothing and publishing of the organizational structure pertaining to functions, job descriptions and organization charts. These changes should improve functional operation of the Company and make all personnel more aware of Company division of responsibilities.

An important problem in the Accounting Department is that the present system does not provide accurate overhead application, specific costs of individual products or responsibility for cost controls. Lack of these essentials precludes determination of profitable or nonprofitable products. More attention should be devoted also to budgets at all levels. When time permits, the accounting system should be revised to provide this desired information. This information will make it possible for management to decide which phases of the business are profitable and to decide on which products to concentrate.

Another important problem which should be considered is that of Inventory Control. The recommendation concerning this problem is that a long-range plan be established which should reflect consideration being given to the effects of methods, standards, process flow, plant layout and production scheduling on inventory valuation.

It is not intended that recommendations not mentioned in this summary be regarded as unimportant. All recommendations in the report should be given thorough consideration. It is strongly suggested that personnel in the Gurley Company review this report with

an open mind so as to weigh fully the value of each proposed recommendation, and that they avoid summary rejection of all recommendations, which appears to have been the action taken toward past survey recommendations.

INTRODUCTION

Purpose

Arrangements for the survey which forms the basis of this report were made by the Department of Management Engineering of the Rensselaer Polytechnic Institute. This survey provided an opportunity for the practical application of theories and concepts gained in the field of Management and Industrial Engineering during the scholastic year.

Personnel Conducting the Survey

Students

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Faculty Advisors

Professor W. F. Spafford

Professor E. H. Van Winkle

Associate Professor H. W. Martin

Scope of the Survey

All operations of the Company, which are located in Troy, New York, were investigated to the greatest detail practicable within the time available.

Method of Conducting the Survey

Two or more afternoons per week were assigned to this survey. The group of student officers would meet with appropriate representatives of the Company to collect data and information by interview, observation and inspection of operations, plant, equipment and records. Once all the pertinent data had been collected, one or more afternoons each week and considerable additional time were utilized to conduct group discussions of various matters reported by individual officers or by a group of officers. The faculty advisors were present for the final presentation of findings, appraisals and conclusions, and recommendations in each subject.

Statements and recommendations concerning organizational and functional operations of the Company have been considered objectively and special effort has been made to eliminate reference to individuals.

It should be mentioned that some of the recommendations listed in the report are the result of ideas advanced by personnel of W. & L. E. Gurley and due recognition should be made of this. It shows that many ideas exist in the organization that may help to improve the Company.

Limitations of the Survey

A major limitation on the survey was the apparent absence of a common understanding by many representatives of the Company of the actual organization and of the detailed mutual responsibilities of individuals and procedures. In different parts of this survey reference to various departments and personnel may vary somewhat; it is felt, however, that the terms used are self-explanatory. This variation is due not only to the non-existence of a recent organization chart and the use of synonyms, but also to the short duration of time for standardization of the terminology used by the several groups of officers reporting on various areas of operations of W. & L. E. Gurley. It must be recognized that in any survey of this type some assumptions must be made; any conclusion based upon a false assumption, however, is subject to error. In those areas in which false assumptions have been made, the Company should ascertain whether its employees are properly informed as to the Company policy and practice or whether there was misunderstanding on the part of the survey group.

Appreciation

The group of student officers and the faculty advisors of Rensselaer Polytechnic Institute wish to express their appreciation for the opportunity to study the operations of a commercial manufacturing plant, and for the whole-hearted cooperation and assistance of the management and employees of W. & L. E. Gurley.

PART I

SALES

Findings

The sales organization of the W. & L. E. Gurley Company is a department under the supervision of the Executive Vice President in Charge of Sales. He reports to the President. The department is divided into three divisions: Engineering Sales, Industrial Sales, and a division called Orders, Billing and Shipping. There is also a sales representative who is located in Washington, D. C., who confines his work to obtaining information of projects upon which the Company might like to bid. This representative also does sales and sales promotion work in the southeastern states. The President of the Company also concerns himself with sales and at times visits various dealers as well as attends conventions and exhibits where the Company has advertising display booths.

The two sales divisions, Engineering and Industrial, operate quite independently because of the differences in the products with which each division is concerned. The Engineering Division is concerned with selling surveying and engineering instruments such as transits, levels, alidades, current meters, water level recorders, weights and measures and other items of like nature. The Industrial Sales Division sells paper testing, textile testing and wind instruments. This division also sells glass reticle products. There are twelve people assigned to the Sales Department, of whom six are in the Order, Billing and Shipping Division and therefore not actively engaged in selling.

Other personnel in the Company assist sales with technical advice, raw data for repair and estimate bids, and clerical and stenographic assistance. The six people actively engaged in selling are: Executive Vice President - Sales, a sales manager and one assistant for both the Industrial and Engineering Sales Divisions, and the Company representative in Washington, D. C. Secretarial and clerical assistance is received from a main office pool. In summary, it was noted that only five people were engaged in actual selling positions; other sales personnel were in supporting roles in Orders, Billing and Shipping.

Planning for the Company's productive level is based upon a sales forecast which is initiated and prepared by the Sales Department. This forecast is in two parts, one prepared by the Industrial and the other by the Engineering Sales Division. The forecasts are prepared in July or August for use in the subsequent calendar year. The present method used as a basis for the determination for the forecast of future sales apparently is for the most part on an analysis of the past five years' historical data. The number of sales of each product by type is cumulated for the previous five years and is averaged. From this average, through experience of the individual sales manager of possible trends, a figure is developed which is used for the sales potential for that product for the coming year. The forecasts for the year then are broken down into quarterly sales expectations. The forecasts are detailed to the extent that the forecast includes the number of sales expected by each individual product by model and by dollar value. When these forecasts are prepared, they are submitted to the Vice President - Sales, and then to the President. It should be noted at this time that

there was very little market research conducted by any members of the sales force which would indicate any systematic effort to determine what the total sales potential for the industry on a national scale might be. There was also no accurate idea as to what proportion of the market Gurley sales would be. This means that it is very difficult to note accurately Company trends as far as sales are concerned; and also very difficult to forecast accurately industry or product trends. The forecast, therefore, was very dependent upon historical data averages and the experience and decision-making of the individuals preparing the forecasts. In some cases the forecasts have been very accurate; other phases have been very far off. When the President receives the forecast he reviews it and holds conferences with sales personnel until all concerned are in accord with the forecast as completely as possible. These forecasts are reviewed quarterly during the year in which they are being used, and necessary revisions are made.

When the forecasts for the subsequent year are accepted, the plans for the productive effort are made on a quarterly basis. All department heads and personnel involved in planning are appraised of the production and sales plans. Budget requests for operation of the various departments are submitted and the actual budgets for the next year's operation are approved and put into effect. The sales forecasts then are the foundation upon which the Company's productive planning and operation are based.

The budget for the Sales Department is authorized by the method described above. The submitted budget was based upon the sales forecast dollar values and also upon the fixed expenses which are neces-

sary for operation. The sales budget is approximately four percent of the total sales. In the Sales Department's budget there is a further breakdown for sub-budgets for the various divisions of the Department. At this point we will show the division of the Budget to the Engineering Sales Division first and also present findings for that division; later we shall present the same facts for the other two divisions of the Department.

Engineering Sales. The Engineering Sales Division has a sales manager and an assistant sales manager and also receives assistance from the Company's representative located in Washington, D. C., who covers the southeastern states for this division. It should be remembered that this sales division is responsible for selling surveying instruments, engineering instruments, weights and measures, current meters and water level recorders. The amount that this division receives as its share of the Sales Department's budget is approximately four percent of the dollar value of the sales which this division has forecast for the year. The money allowed under the budget is used for salaries, various types of advertising and exhibits. The salaries are for the sales manager and his assistant. The money budgeted for advertising is used for the following items: Gurley catalogs, convention expenses, promotional work, exhibits, Gurley instructions, postage, photography, art and engraving and advertising space in various engineering and trade magazines. Advertising advice and releases are done by the Fred Wittner Advertising Agency of New York City, the advertising consultant for the Company. This firm advises as to the best media to

reach prospective customers, arranges for the space in all media and provides recommendations for improvement of the internal sales structure of the Gurley Company. The improvement recommendations concern all phases of the Gurley sales problem. A recent list of sales recommendations for the Gurley Company includes such items as sales organization structure, dealer organization, development of sales, direct mail advertising, revision of present Gurley catalogs and bulletins and other means for interesting prospective customers and inviting inquiries about Gurley products. In addition the Wittner Company prepares news releases on new instruments developed by Gurley and arranges for their publication in newspapers and magazines.

The Engineering Sales Division markets its products through outside dealer representatives and by sales from the home office in Troy. The Company does not operate retail outlets of their own. The dealers are individual operators and operators of large engineering equipment supply houses with widespread branch stores. There are no dealers who handle the Gurley products exclusively. All dealers handle at least one additional complete line of competitor products. The distribution dealers who handle Gurley products are located in nearly all of the major cities in the United States. In some of the larger cities more than one dealer handles Gurley products. In addition to this national system of distribution the Gurley Company has dealers in Canada, Mexico and does export business to many countries throughout the world through an export firm in New York City which handles that phase of the business for the Company.

In some cases the dealers have sub-dealers who are unknown to

the Gurley Company. There is no attempt made by the Company to prevent this practice.

The dealers buy the instruments which they wish to carry in stock for the most part for cash. In some cases when the dealer is small a consignment may be made by the Gurley Company. The cash sales are made from a fixed list price which is set by the Gurley Company as the retail sales price to the purchaser. The price to the various dealers varies normally according to the amount of dollar volume of Gurley instruments sold by the dealer. These varied price discounts to the dealer range from five percent to small dealers to twenty-five percent to larger volume dealers, and to thirty-three and forty percent to foreign firms. The retail list prices from which the discounted prices to dealers are computed are the prices which the Gurley Company rigidly requires all dealers to charge individual buyers for their products.

The method of setting these rigidly held prices is, as far as could be determined, done in the following manner for new Engineering Sales Division products. Direct labor costs plus material cost is added and is referred to as a net cost price; this price then is multiplied by 3.5 to arrive at a selling price. The resultant figure is rounded off and compared with competitors' prices for the same product. The final decision as to the list price is set to compete with similar competitors' products and also priced to emphasize a feeling of quality in the Gurley instruments. As an example, a product which would list at six hundred dollars by the Gurley pricing formula, when compared with a nine hundred dollar list price of a competitor's similar product, would be raised to eight hundred fifty dollars arbitrarily to insure

acceptance of the instrument as a quality product.

There are no formal agreements drawn up between the Company and their dealers except for a gentlemen's agreement which is arrived at through correspondence between the two parties. The most formal agreement included in these letters is the one which pertains to the rigid "single price policy" maintained to the individual buyer.

On occasions where a direct bid is requested of Gurley by a prospective buyer in an area covered by a Gurley dealer, the dealer is contacted by Gurley and requested to follow up on the order; that is, the dealer submits the quotations and pursues the sale. In other cases where a large order is involved, such as in State Highway Departments, the dealers refer the bids to Gurley for final pricing. Here, based on who the dealer is, how large the order is and how much competition is involved, the Gurley Company takes one of the following steps: (i) they may authorize the dealer to discount as he sees fit, taking the lower profit loss himself; (ii) they may dictate a specific quotation assuming any discount loss against the Gurley Company and not against the dealer; (iii) they may agree on a discount with the dealer and split the discount loss with him. Competitor action on large bids has not been very stable in the past and therefore extremely unpredictable, making it difficult to arrive at a good competitive set pattern of discounts in these cases.

A portion of the Engineering Sales business covers repair work. This work normally comes to the Gurley plant for estimate of overhaul and repair costs before a quotation is made. Sales gets a breakdown on labor, hours and material required for each job from the fore-

man of the repair department. Sales then prepares a price quotation on the job. This has proved to be a lucrative part of the business since the plant has not been operating at capacity during the past few years. For this reason Sales has been attempting to contact known owners of Gurley instruments and encouraging these owners to return their instruments to Gurley after a period of use for overhaul.

In addition Gurley conducts a "trade-in" business on instruments. The allowance permitted on old instruments is based upon the age of the instrument and its condition. These instruments are overhauled and sold if their age and condition warrant; otherwise they are cannibalized for useable spare parts.

Known competition in the engineering instruments field consists basically of seven United States firms, two Japanese firms and competition from several European countries. Of the seven United States firms the majority do not compete favorably on quality. The Japanese firms do not compete favorably in this respect either. However, the mere fact that these companies continue to market their products and to stay in business is an indication that they do have a share of the market. They frequently submit quotations for State Highway business along with Gurley and more often than not are the successful bidders. For this reason it appears that either the quality built into Gurley instruments as well as some of the other better instruments is not required for all work or the buyer does not realize the difference between instruments other than price. It also appears that more concerns in various European countries may be selling engineering instruments soon in the United States. This situation could occur if the import tariffs

on this type product were lowered. This possibility exists at this time.

A training program for dealers' salesmen is conducted at the Gurley plant at such time as dealers wish to avail themselves of it. The dealers pay for transportation to and from Troy and Gurley pays the bills in Troy for these salesmen. The course is conducted in a three-day period during which time the men are shown all of the Gurley facilities, what is made, how it is made and what the special features of the various instruments are. In addition the men are indoctrinated in the use and capabilities of each instrument. The course is conducted by the sales manager which helps to establish a thorough understanding between him and these dealers' salesmen. These contacts and understandings may prove beneficial in future business dealings.

The sales manager attempts to make one visit to all dealers once each year for the purpose of clearing up any problems that may have arisen and also to see what their facilities are and how they are displaying and pushing Gurley products. Occasionally the Vice President - Sales, or the President, makes personal contact with dealers in conjunction with trips to conventions. Otherwise personal dealer contacts rarely are made more often than once a year.

Exhibits at conventions of various industries and societies are prepared regularly. These exhibits are handled by Sales in conjunction with top management. Normally the President, the Vice President - Sales, and the managers of the Sales Division will participate and be present at the exhibition in order to meet prospective customers and to discuss the qualities and capabilities of Gurley products.

The manager of Engineering Sales prepares the "Gurley Target" which is more or less a news letter used to distribute general information to the dealers and to the dealers' salesmen. Sales items requiring general distribution are written up here as well as descriptive essays with schematic drawings explaining the use and value of some of the least known or new products of the Gurley Company. About five editions are distributed each year. Resulting questions and comments from the recipient salesmen show that they are of definite value in the educational program of the sales force.

The sales manager prepares for publication the "Ephemeris" and reviews for technical accuracy the "Surveyor's Notebook", copy prepared by the Wittner Advertising Agency. The "Ephemeris" contains various tables and facts of interest and of constant use to surveyors. It is quite valuable in assisting to circulate the Gurley name in the field. The "Surveyor's Notebook" copy is used in advertisements in various magazines.

As was pointed out earlier, dealers are located in many cities in the United States and in Canada. There are some cities, however, that are not covered adequately due to their size. In addition some states which do not have any especially large concentrations of people in the cities are not covered at all. In these areas any orders received are an entirely hit-or-miss proposition where either the buyer has used Gurley instruments elsewhere and desires them again or where the buyer happened to see an advertisement and wrote to Troy for a quotation. The home office handles also local New York State orders when no dealer is involved directly. Some of the dealers are not very pro-

ductive but not much has been done to replace or to stimulate them to a better selling program.

The sales volume for one of the Gurley instruments, the transits, have averaged during fairly stable peacetime years approximately one thousand instruments. The plant capacity is large enough to produce twenty-five hundred of these instruments without too much additional capital investment. This idle capacity is one of the most serious problems of the Company. The reason for mentioning this problem is to lead to a discussion of market research of sales potential for this line of products. At the present time the Company apparently is not completely informed as to the total sales potential for engineering instruments in the United States. There is no accurate information in the Company at the present time as to how much of the sales in this field is made by the Gurley Company. One source of information along these lines, the United States Department of Commerce report on the surveying instrument industry, indicates that several years ago the Gurley Company was selling approximately fifteen to twenty percent of the instruments sold by manufacturers in this country. At present no recent knowledge of the Gurley standing is available within the Company and no definite attempt is being made to obtain this information.

The fact that the average production of Gurley transits tends to be approximately one thousand instruments a year might be significant to the Company if good market research information were obtained. Dealers' sales apparently would follow closely this same stable pattern of sales over a period of years. One comment which the Gurley Company has had from dealers handling their engineering instru-

ments is that "the margins with which they are required to operate in selling Gurley products has been too small".

The sales force in Engineering Sales prepare advertising copy, the "Ephemeris" tables, and at times are called upon to inspect production or repaired instruments and to assist with other technical production activities of the Company. These activities reduce the amount of time which the salesmen may spend in the selling phase of the business.

Industrial Sales Division. The Industrial Sales Division has a sales manager and an assistant. It also receives assistance from the Washington representative of the Company who aids by getting information prior to bid work originating in Washington. This division is responsible for selling paper testing, textile testing, wind instruments and reticles. The Division's budget is also about four percent of the dollar value of the sales which this division has forecast for the year. This money is budgeted for salaries and various types of advertising and exhibits.

Advertising for this division is handled by the Fred Wittner Advertising Company of New York, as in the other division. The entire advertising job is done by the Wittner firm for this division. The advertising for this division is done mostly in trade journals, in electronic magazines, in Gurley catalogs and through advertising that invites inquiry write-ins to the Company. Word of mouth advertising, too, is important. Some of the budget is used for conventions and to pay for exhibition booths at conventions.

The Industrial Sales Division markets paper and textile testing instruments and wind instruments through dealer representatives and also by direct sales from the Troy office. The paper and textile testing instruments are sold through dealer outlets in the following cities: Boston, Detroit, Pittsburgh, New York, Chicago, Los Angeles, Minnesota, Philadelphia. There is also a dealer who handles foreign business and a representative in England. There is a dealer in Syracuse who handles airport instruments only and who has this business exclusively for the United States. In Canada there is a dealer who handles all types of air instruments for the Gurley Company. The Gurley Company sells directly for all reticle business.

The sales forecast for this division is made in the same way as for the Engineering Division. Historical sales data for a five-year period is averaged and according to judgment any trend information is considered also in the approved forecast. The forecast is made for one year and is reviewed quarterly during the year. Pricing of the industrial instruments is done in the same manner as in the Engineering Sales Division. Discounts to dealers for these instruments are from ten to twenty percent of the retail list price and a standard ten percent discount to educational purchasers. There apparently is no attempt to require the dealers to sell these instruments at a fixed retail price. The dealers are allowed to sell at the price they desire. The reticle business at the present time is practically 100% on a customer order basis; so that pricing for that business is done on an estimate and bid basis. The method used to make estimates is to include labor, overhead and a profit in a standard which has been set up

for the various departments which produce these reticles. When the estimate as to how long it will take to produce an order is given to the Industrial Sales Division, this standard department charge is multiplied by the estimated hours, the material cost estimate is added and the estimated bid figure is set. The sales manager estimates that about ten percent of the bids submitted on various jobs result in receipt of a contract. The instrument products of this division are in competition with products of similar nature but the sales manager believes that the competition is not too great. He believes also that the reticle business which the Gurley Company does is not in competition with other producers because of the higher quality work which is produced by Gurley.

As is the case in the Sales Engineering Division, the Industrial Division does not do very much market research as to the total sales volume potential of the industry or to determine the portion which Gurley holds in instrument sales. The reticle business is mostly custom order sales so that research might be difficult in this area. The Division is attempting to develop items such as the binary code disk and resolution targets which could be produced for stock items and could be of repetitive production nature.

The Industrial Sales Division apparently shows a good profit mainly due to the reticle sales orders although it does have idle capacity in the plant in this field.

Order, Billing and Shipping Division. This division is headed by a manager who supervises its various activities and also handles some tasks personally. There are two people in Shipping, one in Orders and

one in Billing.

When an order is received from a buyer it goes to the Order Clerk who prepares the Gurley order form. Should the material be in stock he gives a copy of the order to the Billing Clerk who prepares the invoice and processes it to the Shipping Clerk for actual packaging and shipping. In this case a copy of the order form goes to the sales manager involved. Where the item is not in stock the order form is processed to the sales manager for release. After release, copies go to the assistant sales manager, the plant manager, production planning and control, the executive vice president and others depending on who is involved in the production of the specific item. In addition a copy goes to the customer acknowledging the order and notifying him of an expected delivery date. On all orders from new customers the order is routed first to the Credit Manager for credit release. As soon as the item is produced the normal shipping papers are prepared and shipment is executed.

The manager of this division prepares an operating budget each year for money to cover salaries and supplies for the year. This budget is prepared on the basis of sales forecast for the year and is submitted to the General Sales Manager who in turn submits it to the President for approval.

Appraisal and Conclusions

Sales Organization. One essential for successful sales management is a sound organizational structure. One part of good organization is to have comprehensive job descriptions, setting forth the duties, responsibilities and authority for each position. Such a de-

lineation of duties is not in existence in the Gurley organization at this time. This situation makes it difficult for the present sales personnel to understand fully their complete responsibilities or to know their sphere of authority. The organization in this department is divided into three divisions and is controlled by the Executive Vice President. It appears that each of the three divisions is operating on a more or less independent basis. It is believed that, if the entire Department could be coordinated and integrated more closely through redistribution of duties, a more effective sales program could result. Some of the duties now performed appear to be outside the accepted field of a sales department. These duties should not be in the job descriptions when they are written. Thought should be given to providing the Sales Department with fulltime secretarial assistance. The Sales Department apparently does not have enough salesmen to keep a man in the field visiting dealers, doing market research and in general doing a good selling job to distributors. It is felt that this is one of the essential requirements in the Sales Department at this time in both the Engineering and the Industrial Divisions. Perhaps each Division could benefit by having one additional salesman. If young, aggressive engineers were employed and thoroughly trained in Gurley policy and products, then given a short course in salesmanship of this type product, they could be kept in the field a majority of the time. In this capacity these men would make dealer contacts, market analysis, conduct short training discussions on Gurley's quality selling points for dealers' salesmen, and in general stimulate interest in the Gurley product.

The existing organization appears to be sound structurally.

It is suggested that the overall coordination of the Department be exercised by centralizing a few functions in the office of the Vice President in Charge of Sales. These functions would be to control advertising, and to analyze market research, new product research and the sales forecasts. It is suggested also that perhaps the functions of the Engineering and Industrial Sales Divisions could be more closely united to the point where any salesman on the road could talk to dealers of both Divisions. This integration could be accomplished through sales meetings and by training. There should be strong lines of authority from the Vice President - Sales down through the entire sales organization. This would strengthen the sales organization and facilitate good definite connecting lines of communication.

Sales Forecast. The forecasts now prepared are based on historical sales records for the preceding five years. Market conditions and expected future sales are introduced into the forecasts only through the considered opinions of sales and experienced Company personnel. Very little effort to make a systematic analysis from data collected from outside sources is made. Admittedly, completely accurate data concerning sales or market potential in this field is not readily available. A request for information from the Department of Commerce concerning "Comparison of Company and Industry Sales of Surveying Instruments" resulted in receipt of a letter which stated that the Department of Commerce did not have such information due to the size of the industry. Information could be gathered, however, from dealers, from State Public Works Departments, from users of Gurley products - in fact from all sources that would provide even a small amount of information. The sales

force who are traveling about the country contacting dealers, visiting potential buyers, and so forth, could gather this data. It is understood that this information will not be completely accurate, but it would be more valuable in preparing the sales forecasts than the present method of using considered opinion of sales personnel who are not in touch with the pulse of the market because of insufficient contacts with dealers in the field.

Some disadvantages of the present system are:

1) It is based on opinion and therefore inferior to facts as a basis of forecasting.
2) It requires the expenditure of costly executive time.
3) Breakdowns by product, time intervals or markets for operating purposes are difficult to make.

Sales forecasting is essentially a function of the Sales Department. At the same time the forecast is of such value to other parts of the Company and to the overall success of the Company that it often is considered a top management function, to be delegated but to be supervised by the President. Because of this great importance of forecasting sales it appears that the actual final sales forecast should be prepared at a higher level than is now done. The forecast should be prepared in final form as one composite forecast, by products, for all sales, in the office of the Vice President in Charge of Sales. The methods used in preparing this forecast should be based on market research, historical data, business conditions and Company operation. Periodic review of performance and revision of forecasts should be continued as is done by the Company at present.

The sales forecast in the Gurley business is the basis from which plans for production and operation for the subsequent year is made. Because of this reliance on the sales forecast it is highly important that extreme care and thought and effort be put into the preparation of this forecast.

The conclusions concerning sales forecasting in this company are that although the present forecast is arrived at in a systematic manner there are too few factors considered, and that too much reliance is placed on historical sales data and opinion. The data which seems to be very vital, market conditions, consumer desires and plans, and valuable information which could be gained from the dealers, appears to be not considered to any great extent.

The sales budget which is allowed is based on the sales forecast. The adequacy of the advertising portion of the budget could be determined to a better degree by the two new salesmen who are in the field. They could assist in providing information as to the effectiveness of the advertising program.

Market Research. Since no formal market research program now exists and since almost all data in this field is based on opinion formulated during occasional field trips of Company executives, no realistic planning can be accomplished to predict future sales. This function, possibly placed in the hands of the Vice President in Charge of Sales, could serve the purpose of vitalizing the present predictive capacities to the point where Gurley could forecast market fluctuations and new product needs of customers sufficiently in advance to permit quick production changes, thereby avoiding large and sudden fluctuations

in operations. The two new sales engineers who would be operating in the field almost entirely could be assigned specific functions to monitor sales activities throughout their areas; also they could send back data for correlation and analysis in future use. Some of their specific functions could be: to gather facts on the market potential by areas; to collect data on consumer preferences, habits and attitudes in relation to Company products; to look into customer motivations in order to permit a measure of effectiveness of advertising, sales promotion and dealer sales training programs; to report on dealer activities, making recommendations as to additional dealerships or cancellations based on market requirements or dealers' lack of activity; to gather all data possible on total sales of competitors' items and prices by area; to get facts on possible new uses and users of Company products; and constantly to look into new products based on customer desire.

This data could be correlated and analyzed by the Vice President in Charge of Sales for purposes of studying dealer discount plans; of compiling customer lists and developing sales prospects; of realigning sales territories; of analyzing potential by market areas; of comparing performance with potential; of developing sales performance standards for dealers; of determining new uses for present products and new product lines; of analyzing customer preferences, habits, and attitudes on Company products for possible design changes or advertising material; of making product line studies to eliminate unprofitable ones and to develop more profitable products; of measuring effectiveness of advertising, sales promotion and sales training programs; of surveying customer demand as an aid in long-term forecasting; and of making long-

term forecasts and planning sales to prevent wasteful over-expansion of capacity and to capitalize on market opportunities. Market research may indicate that the market for engineering and industrial instruments is inelastic. If this is the case, and the Gurley Company is enjoying the maximum proportion of the market which can be expected, it might be wise for the Company to stabilize production in this field at that level and exert every effort to sell that stabilized quantity. The Company could plan production on a firm basis and savings could be effected by better plant layout and methods.

Distribution Systems. The present distribution systems based on the more formal system in engineering products and the more informal system in industrial products needs some reorganization. Formal agreements need to be drawn up between the dealers and the Company delineating the specific requirements and limitations on dealers' activities by the Company. These agreements should cover such matters as area-limitations, pricing policies, discount arrangements and dealer-Company relations.

At present dealers' areas are defined loosely although the Company does wish to protect its dealers and give them a fairly exclusive sales area for Gurley products. A thorough market research study could assist in defining areas more exactly and could specify which areas should have more than one dealer due to larger market potential within that area. Those areas and products not covered at all or covered directly by the Company, based on outside inquiry, should be surveyed and dealers should be established.

The present pricing system on engineering instruments, which

holds the price line with all dealers, has advantages in that it makes for good Company-dealer relations. Dealers get to feeling that the Company will protect them against unfair price cutting by other dealers and feel more confident in quoting prices on Gurley products. Disadvantages lie basically in the fact that some buyers expect a discount and will not buy a product without one. Some sales are lost undoubtedly due to this attitude; however, since dealer discounts are not too high in the industry, it is considered better to set prices and gain dealer support. In industrial instruments prices are not set and held by Gurley. In this field of products it has proven satisfactory to let the few dealers that do exist go ahead and sell at their own prices. The practice of permitting dealers to discount engineering instruments to quantity buyers such as State Highway Departments is a good one and actually necessary since competitors are known to do the same thing. As a matter of fact, it appears that this practice should be extended to the point where Gurley itself, based on area market research, should set the quotation on these bids to meet past quotations of competitors and to absorb part of the discount loss itself. This action would help to increase production volume and the resultant reduction in production cost per unit would help to offset the extra allowed discount.

A point which must be kept in mind always in selling engineering instruments at a fixed price is that dealers are being restricted to a specific market which lies in the quality field. Those buyers who buy on price and not so much on quality are normally lost to the Company. In line with the price setting of these instruments, therefore, and if market research indicates that a market does exist for

lower priced instruments, it would be of value to consider the manufacture and marketing of a less expensive line to complement the regular Gurley line. In order to avoid misunderstanding it would be better to use a different name on this new line; and marketing could be through regular dealerships as well as such organizations as Sears Roebuck who now handle less expensive competitor products. This additional dealer organization would enable the reaching of the lower priced market more completely.

The present dealer discount system which gives a fixed discount to dealers but varies from five to twenty-five percent in the United States appears to have been established on a fairly sound basis originally. That is, higher discounts went to the more active dealers. No provision exists in writing, however, which establishes levels of activity versus levels of discounts. Some dealers who have become slack apparently in their sales efforts are getting more of a discount than others who have remained on a level over the years. This condition is now difficult to correct. A firm policy, however, should be set up for all dealers, which would give them sufficient financial incentive to push the Gurley line; and this policy should be implemented over as short a period of time as possible without overly disturbing present dealers. Such a policy could allow, say, five percent up to a dollar volume of one thousand dollars, ten percent up to a dollar volume of four thousand dollars, fifteen percent up to a dollar volume of fifteen thousand dollars, twenty percent up to fifty thousand dollars and twenty-five percent for over fifty thousand dollars. The actual figures should be set, based on past records, possibly just a little

over what would be expected normally in order to get dealers to strive a bit more. This would be in the agreement and would have the effect of urging dealers continually to get into the next discount bracket.

If it is found that dealers fail to increase or hold an expected sales volume level, they should be stimulated and trained; and after that time, if their sales volume remains poor, they should be replaced.

The reticle sales part of the Industrial Instrument Division does not have any dealers at all. Sales are made through the home office and most of them are for non-standard items. The large number of bids being made, compared with the small number of bids actually won, indicates a need for getting out to the field and getting a better understanding of customer requirements. Possibly delivery quotations are not satisfactory. Some prospective customers may not realize fully the capabilities or quality of Gurley products. Here strong efforts should be made to determine new uses and users of reticles with some standardization and eventually leading into regular production dealer outlets as in the other products.

Sales Promotion. The present sales promotion program is based on publication advertising, exhibits at conventions and a limited circulation of various bulletins to dealers and to some schools.

The advertising program, handled primarily by the F. Wittner Advertising Company, appears to be well managed although not enough evaluation is being conducted of the results of specific advertising. Only occasionally has an effort been made to determine the origin of

inquiries on various products, whereas it is possible to invite inquiries in all advertisements with coded inquiry reply forms. These at least would give some indication of the results of various media.

Convention exhibits are considered an excellent means of sales promotion since most of the people in attendance are interested in equipment professionally; and therefore almost everyone contacted is a prospective customer. Here, too, is a good opportunity to exhibit new products with which customers are not as yet familiar. Frequently the personal contact obtained through these exhibits is worth a great deal in future business.

A program aimed at familiarizing all prospective customers at the college level appears to be in order. When students have used a piece of equipment in school and have become familiar with it and with the manufacturer's name, they are more apt to want to use the same manufacturer's equipment later in professional life. Here then is where to reach these future prospects. All schools throughout the country, teaching courses where Gurley products could be used, should be contacted and an enticing plan should be laid out for their participation. For instance in the surveying instrument field a program of possibly donating one instrument to each school, if the school will allow Gurley sales engineers to lecture to the senior class each year on Gurley products, their special features and uses, and to pass out various bulletins and advertising information. At the same time a twenty-five percent discount could be offered to the school on additional instruments purchased. If this proposal seems like too great a give-away, perhaps a more generous discount and trade-in plan could be

set up, without giving the free instruments, but getting the lecture agreement. Financially these plans probably are cheaper than the convention exhibits and will reach actually a large number of future prospects over the years.

Salesman Training. The dealer salesman training program seems to be well laid out in the fields it covers. It should be extended to cover all Gurley products. One difficulty may be encountered due to the reluctance of dealers to pay salesmen's travel expenses to Troy. As a matter of fact some of the present smaller dealers undoubtedly have not sent their salesmen to the course. In order to overcome this problem the two travelling sales engineers could conduct a smaller training program in the field.

Use of the "Gurley Target" to familiarize salesmen with special features of products, new models and new products is considered a good training medium. Information of this type should be continued and possibly enlarged until the travelling sales engineers can get into the field to assist in this type of training.

Training should be placed on a continuing basis so as to help all salesmen to keep up-to-date on latest developments and practices. Especially emphasized should be remedial sales training in those cases where sales have slipped. Training courses should stress the selling of "quality" in the Gurley product since that is the basis upon which the firm has sold their product for so many years.

Recommendations

The following is a summary of the recommendations and proposals which concern the sales organization of the Gurley Company. It is suggested that the Company analyze each proposal and recommendation thoroughly before consideration is given to either accepting or rejecting the proposals.

1) It is recommended that job descriptions be prepared in detail for each position in the Sales Department. At the time these descriptions are written it would be advisable to make a thorough study of how best to assign specific duties to each position so that the best utilization can be made of the abilities of the present employees. Perhaps by judicious assignment of duties some sales personnel may be made more available for outside selling.

2) In order to achieve a more closely coordinated department the four following functions should be assigned specifically to the Vice President in Charge of Sales:

   (a) Market research and analysis

   (b) Sales forecasts

   (c) New ideas for product research

   (d) Advertising

3) Assign secretarial assistance to the Sales Department on a permanent basis.

4) It is recommended that two young engineers be employed, trained as sales engineers and utilized almost fully in the field. One of the new men should be used in engineering sales, the other in industrial sales, but both should be qualified to visit all Gurley dealers in the field.

5) It is suggested that the basis for making sales forecasts include factors in addition to historical data and opinion. It is recommended that market research data, business trends, dealer opinion, customer desires, business conditions, as well as historical data and opinion be included in the basic data used in computing sales forecasts.

6) A market research program should be inaugurated in the Sales Department. All available data sources should be explored for market information. Much of this work would be done by salesmen in the field submitting raw data to the Vice President of Sales for his analysis.

7) It is recommended that definite geographical areas be specified for each dealer. Areas inadequately covered by one dealer should be assigned to two or more dealers. Where market research indicates no coverage, action should be taken to obtain a dealer for that area.

8) It is suggested that non-productive dealers be stimulated by a training program; and, if they fail to respond with increased sales, steps be taken to replace them or to supplement their area with additional dealers.

9) It is recommended that the Gurley Company set a pricing policy for quantity sales bids which offers discounts low enough to meet competitors' prices.

10) Because the pricing policy for Gurley products stresses quality instruments it is recommended that the training program for dealers emphasize and reemphasize the points of quality in the

Gurley instruments which will assist in selling this quality product.

11) It is recommended that a lower priced instrument be marketed under a different name to complement the present line, and to enable the Gurley Company to utilize fully their productive facilities and to compete in this lower price market.

12) The present dealer discounting system should be revised to allow progressive discounts based on progressive sales volume.

13) It is recommended that the Sales Department make an analysis of their present dealer system. After the analysis the sales force should go out and get new dealers to reinforce their present structure. This could be accomplished at the same time that sales areas by geographical limitations are set.

14) The reticle business appears to be one of the best leads for profitable expansion at this time. It is recommended that a salesman be sent out immediately to sell and find out what can be sold and where. It should be kept in mind that a stable repetitive product is needed in this field to stabilize that phase of the business. The feast or famine cycles now experienced may prove to be a bursting bubble if some stable product is not found soon.

15) It is recommended that for a long-range advertising plan, technical schools and colleges be given more adequate coverage to stimulate future sales. Perhaps one of the ideas advanced in the appraisal section could be used.

16) It is recommended that much more contact with dealers and the public be made by the personnel in the Sales Department. The

business trend is swinging now to a buyer's market and the order-taking idea of business during the past few years has, or is, fast disappearing. It is now necessary to sell products; therefore aggressive personal selling is very essential. To accomplish this type of selling dealers must be met and stimulated. Travel also gives valuable knowledge of the trends of consumer thinking which results in good market research.

17) It should be emphasized that one of the functions of sales personnel who are collecting raw market research data is to be alert constantly for new ideas concerning new products which the Company could produce.

18) This proposal would be applicable only after a good market research program indicates that it is feasible. If the research indicates that the market for engineering and industrial instruments is inelastic and that Gurley has captured the maximum proportion of the market which can be expected, then perhaps the Company should decide to stabilize production of these products at a certain level and exert every effort to sell that stabilized quantity. This policy would allow the Company to plan their production on a firm basis and would lend itself to possible savings in better plant layout and methods for this known repetitive production.

The main problems apparently facing the Gurley Company today are (i) a dwindling market for its old line products; and (ii) a failure to realize a greater proportion of reticle bid awards. This situation evidently is being accepted by the sales force as a normal condition

based on the personal feeling that Gurley still is maintaining its place among competitors as far as a percentage share of the market is concerned. No factual data is available to support this contention, however. For that reason it is especially advisable to accept the immediate added expense of the two young sales engineers, with the resultant increase in travel expenditures, so as to be in a position to gather some facts about the market and thereby be able to make decisions armed with more than opinion. The majority of the recommendations made do not point out a need for major changes. It should be noted, however, that the theme of the recommendations is for a change in the sales policies which will aim at producing a more energetic, aggressive, forward and dynamic approach to the marketing problem which confronts the Company at this time.

PART II

RESEARCH AND DEVELOPMENT

Findings

The research and development functions at W. & L. E. Gurley are performed by the following four departments and each will be discussed separately:

Physics and Optical Department

Photoprocessing and Dividing Laboratory

Engineering Department

Design and Drafting Department

In a broad sense it can be stated that all of the Company's research and development work is now being performed by the above four departments. It must not be construed that this section of the report will be concerned with all of the work of the Engineering Department but only that portion that deals with the development of new products and the modification and changes of existing products. The engineering functions will be discussed in the Engineering Chapter of this report.

Before a discussion of the Research and Development functions is initiated, the definitions of these functions will be stated.

Research: The attempt to acquire knowledge through systematic investigation.

Fundamental Research: Unlimited systematic inquiry into an unexplored field of knowledge in the hope of achieving tangible results.

Applied Research: Systematic inquiry into a field of knowledge for the

purpose of achieving specific results.

Development: The solution of a specific problem through the systematic application of knowledge derived from experience, research and/or the study of fundamental principles.

Facilities Provision: Preparation, fabrication, modification or procurement of facilities needed or used for research, study or development purposes.

Physics and Optical Department. The Physics and Optical Department consists of one Research Physicist as head of the department with three assistants. The head of the department reports directly to the President. This department is located on the first floor of the Johnson building with the machine shop and laboratory work areas located on the second floor.

It must be noted that this is a small company and therefore cannot afford to sponsor a Research and Development program as it is understood in the modern sense. For this reason no fundamental research projects are sponsored by the Company. Only those projects which the Company feels absolutely necessary for improvement of their own products are sponsored; however, if financial backing is obtained from outside sponsors, projects are undertaken for them within the capabilities of the department. At the present time enough such projects are on hand to keep the few people in the department busy.

The facilities provision of the department are not too extensive since funds are limited. This lack of facilities at times presents a hindrance to rapid solutions to the many problems that

arise in the research and development field. The members of the department must use ingenuity in devising various facilities provision in order to carry out their work which results in a slowing down of the overall work output of the department.

The department at present operates in the following manner. The department head concerns himself with the scientific aspects of all projects, while his assistants aid him in producing the facilities provision and the actual physical items that the department head designs. Once the pilot models have been developed the sponsors of the project are consulted for their opinion regarding the functioning of the models and the fulfillment of their needs. If approved by the sponsors and a small order is received, this department fulfills the order by producing the required number of items. However, if a large order is received, the normal production facilities of the Company will be required for the fulfillment of the order. The exact procedure followed from pilot model to actual production by the normal facilities of the Company is covered in the Engineering Chapter of this report.

The department is responsible for:

a) Physics and Optical research and development

b) Investigation of present products with a view for new material substitution, modifications and simplification.

c) Preparation of estimates for research and development projects.

Each of these responsibilities will be discussed separately below.

Physics and Optical Research and Development. The work of this department in physics and optics can best be noted by listing some of their past and present projects. During the past years the department developed:

1) A one-second Theodilite for the United States Army.
2) A night transit for the United States Army.
3) An Optical linear measuring system for the Pratt and Whitney Machine Company of Hartford, Connecticut.
4) A variable powered focusing eye piece for the Gurley instruments.
5) An alidade with a very high field of vision.
6) An Optical plumb bob.

Present projects in various stages of development are:

1) Wide-angled projection lens system
2) Special bore sighting and inspection telescope for the United States Army
3) Telescopes that focus from 19 inches to infinity for use in industry and surveying
4) Level instruments that focus from 16 inches to infinity. The improvements in focusing distance is a revolutionary phase since telescopes normally focus from six feet to infinity.
5) Circular measurement instruments for industrial use to read to one second of arc.

Investigation of Present Projects. The department is doing very little or practically nothing in regards to substitution of new materials, modification and simplification. This may seem a little harsh but it must be remembered that this department is constantly busy with new projects which leaves very little time for studying present products.

Preparation of estimates. Whenever a bid is received for a new project, the department head is called upon to prepare an estimate as to the possible length of time needed to complete the research and development stage, the cost of the research and development and the cost of producing pilot models and subsequent models. All of the above estimates are based on material and labor costs only; burden costs are applied at a given predetermined rate set by management. This estimate then is presented to management with the supporting data for their decision.

Photoprocessing and Dividing Laboratory. The organization of the Photoprocessing and Dividing Laboratory is illustrated in the Organization Chapter of this report. The personnel assigned to the Laboratory are people of varying experience and capabilities. A few of the people are somewhat specialized in specific lines but all are expected to develop a general knowledge of all of the laboratory equipment and procedures. It is the intent of the department head that there will be at least two technicians qualified for each type of equipment and procedure.

The head of the department reports directly to the President. It will be noted in the Organization Chapter that under the head of

the Photoprocessing and Dividing Laboratory is Department 18A (Reticle) which is a production department. The operation of this department will not be discussed at this time since this section of the report is concerned only with the Research and Development functions.

As was noted in the earlier portion of this chapter, due to the size of the Company and the scarcity of funds no fundamental research projects are sponsored by the Company. The Company has developed considerable know-how in the field of Photoprocessing and Dividing and is far ahead of others in this type of work. As a result the Company does sponsor limited applied research and development projects; however, the majority of the applied research work performed in the Photoprocessing and Dividing Laboratory is done on a contract basis only. These systematic inquiries into a field of knowledge for the purpose of achieving specific results are continued until funds are depleted and at this time the results are examined by the sponsor as to the progress made and it is left entirely up to the sponsor as to the continuance or discontinuance of the systematic inquiry. The majority of the work performed by the laboratory is development work for prospective customers who inquire into the possibility of the Laboratory solving a particular problem. These problems are analyzed and solved by the photo laboratory. Results are submitted to the customer and if it meets with their approval, a substantial order may follow; however, in all cases the customer pays for the development costs incurred. The department is responsible for:

a) Photoprocessing and dividing research and development

b) Preparation of estimates for research and development

projects and estimates of later production of these products.

c) Setting up the standards of performance, processes and procedures for Department 18A (Reticle Department).

Each of these responsibilities will be discussed separately below.

Photoprocessing and Dividing Research and Development. It can be stated that the laboratory is responsible for all the research and development in photoprocessing and dividing at W. & L. E. Gurley. The laboratory is responsible for the determination of various means of reproduction of various patterns or reticles. This reproduction may consist of either photographic, etching, mechanical or high vacuum techniques or a combination of such methods. Described below are a few of the many reticles and patterns reproduced on glass by Gurley.

1) Binary code transducer disc - 13 annular rings, each containing alternating opaque and transparent sectors. Number of sectors doubles with each succeeding ring progressing outward 2, 4, 8, 16 . . . 8192 in outer ring. Associated photocells and relays permit electrical measurement of angles.

2) Resolution Test Target consisting of progressions of line spacings by sixth root of two per step. Span of total series in 36 steps, or a total of 64 to one line spacing. Vertical and horizontal lines are provided in each step as a check on astigmatism. This pattern, employed in collimators, in testing the limits of resolution of precise cameras, lenses, telescopes, etc., can be reproduced at various size reproductions and angular projections.

3) Precise Rectangular Grid on Microscope Slide - a grid of 1012 squares was placed on standard 1" x 3" laboratory slide. Grid

itself is about 23 by 24 mm., containing more than 20,000 items of dimensional information and more than 7,000 symbols. Smallest numbers are .04 mm. high and .017 mm. wide. Maximum accumulated error in 44 mm. is less than 0.1 mm. Produced with cemented glass cover, this slide was designed for dimensionally locating microscopic particles in slide specimens by substituting grid for specimen slide and examining it under high magnification. Present projects in various stages of development are:

a) Rhodium Plating of Binary code wheels

b) Resolution Targets by use of diamond cutting to replace present photo duplication

c) Electroforming of precise screens

d) High vacuum processes

e) Metallic images fixed in glass.

Preparation of Estimates. The preparation of estimates for bids for new projects is by far one of the major functions of the head of the Photoprocessing and Dividing Laboratory. The requests for estimates received by the Sales Department are screened by the man in charge of Specialty Sales and those projects accepted by him are forwarded to the head of the Photoprocessing and Dividing Laboratory for preparation of estimates. Upon receipt of the bid, the head of the Laboratory prepares an estimate of the length of time needed to complete the development of the project, cost of development and the cost of producing pilot models and subsequent models. All of the above estimates are based on material and labor costs only. Burden costs are applied at a predetermined rate set by management. This estimate is then presented to the customer for their acceptance or

rejection. These projects bid on are specialty products and never have been produced before by Gurley; therefore it requires a great amount of attention because the production department is later bound by these estimates. Approximately forty percent of the department heads time is spent on these estimates.

Setting the Standards of Performance, Processes and Procedures for Department 18A (Reticle). The laboratory is responsible for setting the standards of performance, processes and procedures for Department 18A (Reticle). This procedure is followed since the laboratory does all the development work for all projects that eventually are assigned to this department. When a production order is received the following steps are taken by the Laboratory and the results are turned over to Department 18A:

1) Blueprints stating tolerances, specifications and kinds of materials are procured from the customer.

2) Glass negatives are produced.

3) Necessary tools, jigs and fixtures for production are fabricated.

4) All special emulsions are prepared

5) Inspection tests and procedures are developed

6) Layout and process flow are determined

7) Procedural steps are written out and explained to the foreman in charge.

8) Standards of performance are determined on past performance, experience and standard components.

9) Preparation of schedule and production control boards.

The Photoprocessing and Dividing Laboratory's relation to Department 18A is identical to the relation between an Engineering and Planning Department and a Production Department in modern industry. The Laboratory performs all of the functions of an Engineering Department in regard to the Photoproduction Department 18A. Some of the functions performed are:

a) Maintains a file of master reticles and glass negatives

b) Maintains production boards

c) Schedules production

d) Maintains records of rejects

e) Maintains photo supplies

Engineering Department. Since the organization and functions of the Engineering Department are covered in the Engineering Chapter of this report, they will not be duplicated in this section. Only those functions performed by the Engineering Department that are concerned with Research and Development will be discussed at this time. It would be well to repeat that the department is not very large and consists of one engineer as head of the Department and six assistants. The head of the department reports to the President.

The department is not responsible for any fundamental or applied research work. The development work that the department does is not very extensive due to the size of the department and the number of other functions that it is responsible for. At present the department is developing an economical model transit and leveling head. These projects are progressing very slowly for the above reasons of size and other responsibilities.

Design and Drafting Department. The organization of the Design and Drafting Department is illustrated in the Organization Chapter of this report. The department consists of one Chief Design Draftsman and one assistant draftsman with the chief draftsman reporting directly to the President. The department is responsible for:

1) Producing drawings as may be assigned by the Photoprocessing and Dividing Laboratory.

2) Producing design drawings as may be assigned by the Physics and Optical Department.

Each of these responsibilities will be discussed separately below.

Drawings Assigned by the Photoprocessing and Dividing Laboratory. The Chief Draftsman at times functions in a staff capacity to the Photoprocessing and Dividing Laboratory. When the Laboratory is considering estimates for new projects, the head of the Laboratory will request the Chief Draftsman to investigate the possibilities of producing the master drawing to high dimensional tolerance. The Chief Draftsman takes the specifications for the project, investigates and interprets them and then advises the head of the Laboratory as to the feasibility of drawing, labor and material cost.

Whenever a precision glass negative which is used in the production of a reticle is needed by the Laboratory, the draftsman prepares a special drawing to high dimensional control, featuring great contrast and stability. This pattern is turned over to the Laboratory where it is accurately reproduced in miniature on glass. The patterns that the drafting department must produce from specifications are those of a great amount of widely varying detail.

Drawings Assigned by the Physics and Optical Department.

The Chief Draftsman's work for the Physics and Optical Department varies from design sketches to working drawings. It is his responsibility to aid the Physics and Optical Department in producing the drawings for any projects. This may vary from almost rough drawings for producing a pilot model to extremely accurate drawings and specifications to be used in filling small order contracts. These accurate drawings and specifications are submitted to the Engineering Department whenever any pilot model goes into mass production.

In making the drawing from the raw data the Chief Draftsman is responsible for the following:

1) The design to result in a minimum of materials cost and a minimum work content consistent with the proper functioning and appearance of the product.

2) The product designed be within the productive capabilities of the Company.

The raw data submitted to the Draftsman by the head of the Optics Department consists only of the optical systems to be incorporated in the end product and a rough sketch of the end product. It therefore is the responsibility of the Designer to design the product around the optics systems.

Appraisal and Conclusions

It must be remembered that the research and development department of an organization is its most important department. A productive organization is a dynamic organization capable of growth or

decline depending upon its vitality and its consequent ability to react to its competitive and economic environment. The salient factors in determining the vitality of a productive organization, and consequently its ability to react favorably to adverse competitive and economic conditions, are the vitality and effectiveness of its research and development activities. To be vital and effective a research and development activity must be adequately staffed, have high personnel morale, be required to perform the lowest practical minimum of routine work and have a well balanced and controlled program of fundamental and applied research on which to base the developmental planning of new and improved products and processes which is essential to the vitality of the productive organization it services.

From observation it was noted that the responsibility for various areas of research and development wasdelegated to several departments with the department heads reporting directly to the President. This practice results in increasing the span of control of the President, thus weakening the effectiveness of the research program. It is believed these functions at Gurley are similar in nature and can very easily be controlled by one department head reporting directly to the President. This would facilitate the coordination of all research and development and allow the President more time for other important policies and decisions. By this we do not mean that an additional person be assigned this responsibility but that one of the present department heads be given the additional function of coordinating and controlling all research and development.

At the present time there is no formal plan or schedule of

research and development for any of the departments performing this function which results in poor control and coordination of the work. Lack of any central planning is evidenced by the duplication of effort in the field of simplification of present products. Even though one of the primary responsibilities of the Physics and Optical Department is the study of present products with a view to simplification of design and manufacturing processes, the Engineering Department is engaged in the design and development of an inexpensive transit and leveling head. Although this is not basically wrong for the Engineering Department to be assigned development work, the situation at W. & L. E. Gurley is such that there is an adequate staff of development personnel available in the Physics and Optics Department, whereas the Engineering Department does not have enough personnel to be assigned to development work as a primary responsibility which results in the slowing of all work output of that department. Therefore it is concluded that all development work on industrial and engineering instruments be made the responsibility of the proposed Research and Development Department.

If the responsibility for all Research and Development were coordinated under one head, all work could be scheduled with periodic progress reports submitted to the President; this would give necessary control over the activities of the department.

The heads of the Physics and Optics Department and the Photoprocessing and Dividing Laboratory do job estimations for prospective development projects; however, it was found that the head of the Photoprocessing and Dividing Laboratory has been using approximately forty percent of his time on this type of work. A good part of this esti-

mation is routine computations and it is believed that most of this could be done by an assistant with final approval by the department head. This would allow the department head more time for his basic responsibilities.

There is very little consideration being given to study of present products with regard to simplification, use of new and cheaper materials and modification of present manufacturing procedures. If an organization desires to compete favorably with its competitors, it must constantly study present product specifications, processes and materials with a view to reducing costs. Without this constant review, practices "grow up" for using more expensive materials and tighter tolerances than required for proper functioning of the product.

The Physics and Optics Department and the Photoprocessing and Dividing Laboratory operate as very smooth and coordinated teams. The department heads concern themselves with the scientific aspects of all projects while their assistants aid them in producing the facilities provisions and pilot models. The subordinates are very capable men and need very little supervision in their work.

As noted in the findings, the Physics and Optics Department and the Photoprocessing and Dividing Laboratory are functioning as production departments for small orders, thus detracting from their primary purpose of Research and Development. This practice of utilizing Research and Development personnel for routine production work is responsible for slowing down the research and development program. Another factor responsible for the slowing down of the Physics and Optics program is the lack of adequate facilities provision. The

assistants must improvise facilities provision in order to carry on their work. This is a result of the lack of basic equipment and old and worn equipment presently being used which requires time and effort to properly align and adjust to meet specifications.

It was observed that the facilities of the Photoprocessing and Dividing Laboratory are excellent. The Laboratory is airconditioned, well lighted, spacious and has the capacity for handling more work without any expenditure of funds. Since Gurley has acquired a favorable reputation in the reticle field, it would be advisable to strive for more projects for this activity. The Laboratory's know-how, excellent facilities and unused capacity would be a fine subject for a progressive selling program by the Sales Department.

The organization chart shows that the design draftsman reports directly to the President. From investigation, however, it was found that he receives all his assignments from the Physics and Optics Department and the Photoprocessing and Dividing Laboratory. With a central control for all Research and Development work the draftsman could report directly to the head of the Research and Development Department on an equal status with the two departments from which he receives all his assignments.

As explained in the Engineering Section of this report, a conference is held whenever a new product is turned over to Engineering for production. One of the subjects of this conference is the incorporation of standard components in the end product whenever possible without interfering with the proper functioning or appearance of the product. This conference could be simplified if the design

draftsman were required to refer to available standard component data before incorporating any completely new components into the design of an end product. The designer must be required to incorporate standard predesigned components into the end product designed whenever it is possible to do so without interfering with the proper functioning of the product. A record of standard component data is available in the Engineering Department.

Recommendations

The following is a summary of the recommendations which concern the Research and Development organization of W. & L. E. Gurley:

1) It is recommended that the name of the Physics and Optics Department be changed to Engineering and Industrial Instruments Division.
2) It is recommended that all research and development work be placed under one head reporting directly to the President and consisting of three divisions as follow:
    a) Engineering and Industrial Division
    b) Photoprocessing and Dividing Laboratory
    c) Design Drafting Division
3) It is recommended that job descriptions be prepared in detail for each position in the Research and Development Department.
4) It is recommended that Development work be scheduled and that periodic progress reports be made. The control board in the Engineering Department could be used for this purpose.
5) It is recommended that the present development work being done by the Engineering Department be turned over to the Research and

Development Department.

6) It is recommended that the Research and Development Department turn over all production work to the Plant Manager.

7) It is recommended that the Reticle Department (18A) be assigned as the responsibility of the Plant Manager.

8) It is suggested that bids for development work be computed with a view to purchasing necessary facilities provisions. If that is impossible, a long-range program should be instituted to completely modernize the facilities provision in the Research and Development Department.

9) It is proposed that a study be made with regard to improving and redesigning the present products as to simplification, use of new and cheaper materials and modifications of present methods of manufacture.

10) It is recommended that the operating performance standards be studied so that present tolerances, as specified, be evaluated with regard to the necessity of being so rigid to avoid exceeding process capabilities.

11) It is recommended that design draftsman be required to incorporate standard parts in all new products whenever possible.

In conclusion it must be stated that regardless of how dynamic a Research and Development Department is, it must be aware of the consumer market so that they can plan Research and Development to satisfy these needs. One of the best ways in which they may become aware of these needs is through close liaison with an energetic and aggressive sales department.

PART III

PLANT LAYOUT, PROCESS FLOW AND MATERIALS HANDLING

Findings

Plant Layout. For over onehundred years this company has been manufacturing surveying instruments, with a trend in recent years toward specialization on custom machine jobs, reticle work and photo-engraving. The major portion of the instrument manufacturing has consisted of the following items:

1) Transits, alidades and levels
2) Wooden tripods, geodetic rods, Philadelphia leveling rods, stadia rods and plans table outfits
3) Compasses
4) Current meters and wind instruments
5) Hook gauges and graphic water level recorders
6) Densometers
7) Standard weights and measures

The efforts of the entire organization since its founding in 1845 seems to have been concentrated on one common goal, namely the accuracy and quality of their instruments. Although the Company still upholds this fine reputation for precision instruments, the physical plant itself has shown little or no modernization since the present buildings were erected ninety-three years ago. As a consequence the plant layout appears to have come about as a result of evolution rather than planning. In fact the plant layout showing the present location of machinery and equipment never has been committed to any formal

drawings. Drawings III-1, 2, 3, 4 and 5 were developed during this survey giving the plant layout in detail.

The present plant occupies the following buildings:

1) Main building - Fulton Lot Building and the Johnson Building - all four stories in height.
2) Parker House - A three-story former private residence.
3) Garage - Two stories

a) Main Building. The ground floor of the main building contains the office spaces and the shipping room. On a half level below this floor is located the boiler room, foundry and lower automatic room, which contain the only machinery on the first floor. At the present time the foundry is used only intermittently to make simple lead castings. The basement under the offices contains the collimnating equipment. On the side of the building that fronts on Fifth Avenue there is a florist shop, a broker's office and a wallpaper store. The Gurley Company receives a modest rental amounting to a total of approximately $2,200 per year from these tenants.

The second floor contains a machine shop, a boxmaking shop, a clubroom, an automatic room and a storage room for old records.

The third floor is occupied by the woodworking shop, the assembly department and a finished stock storeroom.

The fourth floor contains the paint shop, plating shop, wood finishing rooms (fire regulations require the painting facilities to be located on the top floor), drafting room, repair department, plant manager's office and an engineers' machine shop. The space designated

as the Engineers' Machine Shop consists of miscellaneous unused test equipment belonging to Department 7 but unclaimed by the latter.

This building is serviced by a small elevator, capacity of which is 2,000 pounds, and is connected by enclosed catwalks at each level with the adjacent Fulton Lot Building.

b) Fulton Lot Building. The ground floor of this building contains a machine shop, Department 4, photoengraving shop and dividing rooms.

The second floor contains the tool room (jigs and fixtures), a tool crib, rough stockroom (metal bar stock, paints and oils).

The third floor contains the Maintenance Shop, wood stock storage, wood kiln and a wood finished stockroom.

The fourth floor contains the lens grinding, reticle shop and the vial room (leveling bubbles).

c) Johnson Building. The ground floor contains a machine shop, Department 4, and Department 7 offices. The second and third floors contain the shops and laboratories of the Research and Development Department. The fourth floor has been utilized for the storage of miscellaneous junk with little or no scrap value. The basement has a collimmating room and a stockroom (rough bar stock) used by Department 4.

d) Parker House. This building joins the main building on the northwest corner and was once the private residence of the Gurley family. The building is of sound construction but at the present time

is used only for storing ancient records, magazines and obsolete foundry patterns. The rooms are practically empty and the building is in use so infrequently that heat is provided rarely.

e) Garage. Adjoining the north end of the Fulton Lot building is a large two-story structure which is used by the employees as a parking area. It has a large entrance facing the alley. The former owner of the garage had commenced to install a ramp for two-level parking but left the job uncompleted. The garage is unheated and contains a considerable area (6,250 sq. ft.) which could be converted into machinery or storage space.

The lack of a positive modernization program for plant layout is one of the factors contributing to the difficulties which the Company has experienced in recent years. To emphasize the deficiencies of the present plant layout the following two areas most affected have been selected for detailed analysis.

1) Machine Shops (Department 4). The Machine Shop is peculiar in that it occupies different levels in three separate buildings. The total floor space is 14,100 sq. ft. It is situated in the lower automatic room and the second floor of the main building, the first floor of the Fulton Lot building and the first floor of the Johnson building. In reality the present plant layout cannot be classed as either a process or a product controlled layout. There is neither a grouping of similar type machines into a single area nor a sequential arrangement of machines in the order in which they perform operations on the production items. Although a number of modern

machines are being used, the age of the buildings and the lack of structural alterations has resulted in many instances in the location of these machines being dictated by the available foundation facilities rather than by their contemplated usage. Machinery located in the shops is of all types, models, ages and condition of repair. It appears that some of the equipment is actually unserviceable and could not be repaired economically. For example, a large turret lathe, #416 in the Johnson building, is inoperative and in a partially dismantled condition. Other machines are maintained, although used only once or twice a year, for production items in extremely limited quantities. Some machines are not used for their design purpose; e.g., a large lathe, #168, Johnson building, first floor, is being used exclusively as a grinder to remove burrs from small parts. The great variety of type and condition of the equipment makes the overall picture of dubious value. Each piece of machinery would have to be analyzed to get the true picture of its worth.

2) Woodworking Shop (Department 21). The woodworking shop likewise occupies three different floors in two separate buildings. Total floor space is 9,450 sq. ft. This department has a boxmaking room on the second floor, woodworking space on the third floor and the wood finishing rooms on the fourth floor of the main building. In the Fulton Lot building, on the third floor, are located the wood stock, wood finished stockroom and the wood kiln. At first glance it appears that the woodworking shop is a product-controlled layout with spaces designated for certain products: tripod shop, cabinet shop and boxmaking

room. The work on these products, however, is not confined to these spaces alone but is done on machines in various locations throughout the Department, as illustrated by the process flow chart of the tripod legs. Many of the machines appear to have been located in a random manner wherever space was found to be available. The boxmaking room contains only three machines: a tumbler used by the Machine Shop; and two power saws. This room is used to cut lumber to rough lengths for storage in the kiln and to make shipping boxes and crates.

Process Flow. To illustrate the typical flow processes in the plant, flow charts were constructed and appear at the end of this part of the report for the following parts:

1) Main plate (snap bezel type)
2) Socket and spindle
3) Main tube (dumpy level)
4) Tripod legs.

These parts were selected as they constituted the only portion of the production of the surveying instruments that actually was being manufactured at the time that this study was being made. Rough stock for all metal work is drawn from the stockroom on the second floor of the Fulton Lot building or the basement of the Johnson Building. Rough castings are delivered normally to the cognizant shops on receipt from the shipper and then are permitted to be stacked in the aisles awaiting the first operation, regardless of how long the time interval may be.

All work is done in batches of varying sizes and is not

moved to the subsequent station until the previous operation on the entire batch has been completed; i.e., batch size for the main tube (dumpy level) was for one hundred pieces. One man performed all but three of the twenty-four operations on this part (Op. 18, 19, 20). The in-process time for these one hundred tubes was estimated by the workman to be two months.

Because of the peculiarities of the layout of the Machine Shop, transportations for many parts are exceedingly long. As an example, the first two operations on the spindle are performed in the Fulton Lot building. Then for Operation 3 the parts are carried to the lower automatic room (Main building). These parts are returned to the Fulton Lot building for Operation 4 and subsequently moved across the street to the Johnson building for Operations 5, 6 and 7. A return is made to the Main building for assembly or storage. Total transportation involved is approximately 920 feet for seven operations.

Materials Handling. Materials handling for the Machine Shop (Department 4) and the Woodworking Shop (Department 21) illustrate the present materials handling situation.

The main stockroom for the Machine Shop is located on the second floor of the Fulton Lot building. A second or auxiliary stockroom is located on the basement floor of the Johnson building and contains rough metal stock which the main stockroom cannot take either because of excessive weight of the material or lack of sufficient storage space. Raw material for the main stockroom is received by truck in the alley between the Fulton Lot building and the main building,

and from here the heavy, bulky material is raised to the second floor with the aid of a small hand-operated hoist. Material to be stored in the basement of the Johnson building is carried by hand through a sidewalk grating and placed on racks. This room is unattended.

W. & L. E. Gurley purchases all the castings that are needed for the manufacture of their products. When these castings are received, they normally are delivered to the work station that eventually will use them, where they are stored in any convenient space. At other times the smaller castings are sent up to the finished stockroom to await issue. As far as could be determined, no rough castings are stored or drawn from the main stockroom.

The machine shops of Department 4 must draw their rough metal stock from either the main stockroom or the basement stockroom. Heavy metal stock for use by the lower automatic room or the ground floor machine shops must be lowered by the same hand-operated hoist described above.

Lumber for the woodworking shops is stored on the third floor of the Fulton Lot building. When it is received it must be hoisted to this level by hand with the same hoist that is used for the metal stock. Handling lumber in this manner is awkward and difficult for some of the pieces handled are over fifteen feet in length. The lumber which is used for the tripod legs follows a somewhat different route. This lumber is delivered in various lengths to the courtyard of the main building and then is hoisted by hand to the boxmaking room on the second floor. Here the lumber is cut to rough lengths for the tripod legs. These smaller pieces are taken by hand to the third floor

of the Fulton Lot building where they are placed in the drying kiln.

When lumber is placed in process, it must be carried by hand or loaded on a small handtruck and taken across the catwalk to the Woodworking Shops.

Material in-process, both for the machine shops and the woodworking shop, is carried by hand or in small tote boxes from one operation to the next. The man completing the last operation carries the work-in-process to the next succeeding work station. Thus, if the batch size is large, a skilled machinist may spend considerable time and effort in transporting these in-process parts, as illustrated by the 920 feet of transportation connected with the manufacture of the spindle.

Appraisals and Conclusions

Plant Layout. The present plant layout is not defineable by modern standards. Its heterogeneous nature is a product of the antiquity of the buildings and the lack of a positive modernization program. The present buildings were designed to hold machinery of the type that was used a hundred years ago. Any heavy new equipment which the Company has acquired has had to be located wherever suitable foundations existed. Much of the machinery space is occupied by old machines whose present economical use is doubtful. As a result the Machine Shop Department is spread out among a variety of locations and occupies more space than is really needed. Such a layout hinders supervision, lengthens transportations and complicates materials handling.

The Woodworking Department (Dept. 21) being smaller, is not

handicapped as much as the Machine Shop by the present layout but its materials handling problem is equally bad. The size of the other departments and the nature of their work is such that they suffer to a lesser extent from the deficiencies of the present plant layout. Thus it appears that a revised layout, if not of the entire plant, of the Machine Shop Department at least, would contribute considerable savings through more efficient supervision, reduced transportation and simplified materials handling.

Process Flow. It was felt that by following a few actual parts through the shops a more accurate picture of the operations could be made. At the time that these parts were being processed a priority job for the International Business Machines Company took precedence over the level and transit work, necessitating a long in-process time, as was noted during the survey.

A multi-story manufacturing layout, subject to expanding and contracting production , produces a flow process which in the case of the Gurley Company is both time-consuming and awkward for batches of in-process work being moved from one work station to the next. Transportation of the parts in tote boxes was found to be satisfactory although at times awkward and time-consuming for one man to handle.

A great deal of work was not attempted on a proposed flow chart since the majority of the difficulties associated with the flow of material and the handling of this material all stemmed from inadequate plant layout. It can be seen from the flow chart summaries that transportation constitutes the greatest factor in the interruption

of work and the resultant long in-process time. No attempt was made to follow all the great number of parts that finally reach the assembly line on the third floor of the main building, since the parts selected for the flow charts displayed a clear picture of the difficulties encountered.

Materials Handling. Materials handling of both the rough metal stock used by the Machine Shop and the lumber used by the Woodworking Shop has been made excessively awkward and complicated by both the locations of the stockrooms and the layouts of the shops themselves. The heavy metal stock when received by the stockroom on the second floor of the Fulton Lot building must be hoisted by hand - a slow and awkward process. The stock being received by the stockroom in the Johnson building must be carried down a flight of stairs to the basement. The material stored in these rooms is used by all the machine shops of Department 4. Thus, a machinist working on the first floor of the Johnson building may have to go all the way to the second floor of the Fulton Lot building to draw his stock; or a machinist working on the second floor of the main building may have to go to the basement of the Johnson building to draw his stock. The present system of storing rough castings at the working station, when they are received from the vendor, not only clutters the shop but hinders stock control. It appears that a centralized machine shop with a nearby centralized stockroom would eliminate many of the difficulties encountered with the present system.

The procedure of utilizing the machinists to transport work

in-process to the next work station is extremely time-consuming with the present plant layout. A revised layout would reduce much of the transportation now required for work in-process.

The Woodworking Shop must hoist its lumber by hand to the third floor of the Fulton Lot building and to the second floor of the main building. This job becomes increasingly difficult in view of the length of much of the lumber loaded at these two stations. The box-making room being on the second floor is isolated from the rest of the woodworking department and complicates the handling of the tripod lumber. The crates and boxes which are made here could just as well be made at any location since only two machines are used. In order to reduce the amount of hoisting and handling of the lumber used for the tripod legs, the cutting of the rough lengths should be done at a location near the kiln. This location near the kiln and wood storage area, would make a logical location also for the performance of the boxmaking functions.

Recommendations

1) It is recommended that, after the Gurley Company has decided upon what level they are to stabilize the production of engineering and industrial instruments and reticle products, a thorough study of the economic utilization of all the present machinery be made with the aim of disposing of all the obsolete and unnecessary machines. This would include the study of the possibilities of replacing many old machines with fewer new ones, capable of much more flexible operation. When the machine and space requirements for the desired

production have been determined, a new or revised plant layout can be considered.

2) Since there is little doubt that the entire present plant layout is obsolete when compared with modern standards, it is recommended that the Gurley Company build a new modern plant on the outskirts of the city. The present mid-city location is highly undesirable because of high taxes, typical city traffic congestion and the lack of room for future expansion or major alterations.

3) Since Recommendation No. 2 would entail a large expenditure, probably well beyond the means of the Company, it is felt that the next best thing would be to spend a moderate sum to revise the present plant layout. Since no study has been made as recommended in No. 1 above, the suggested plant layouts as shown by Drawings 6 and 7 and the following explanation are designed to include all presently assigned machinery:

a) Make the entire first floor of the main building available for all the machinery of Department 4. This could be accomplished by moving the office spaces to the second floor of the main building and/or to the Parker House. This, of course, would mean that Gurley Company would have to eliminate the three rentals; since the income derived from them is so small, this is not considered to be a disadvantage. This plan would call for relocating all of Department 4 on the first floor of the main building.

b) If management feels that some office space is needed on the first floor for convenience in conducting business, an alternate revised layout of the first floor of the main building is offered.

Make 6,500 sq. ft. of area of the first floor of the main building available for machinery of Department 4 by relocating the offices to the Fifth Avenue side of the main building and the Parker House as shown in Drawing 6. It is felt that these new office spaces would be an improvement in themselves. The 6,500 sq. ft. of floor space gained by the above layout provides sufficient space to contain all the machinery presently used by Department 4, which now is located on the first floors of the Fulton Lot and Johnson buildings. The space being utilized by these machines is approximately 4,500 sq. ft.

c) Centralize the rough stock room by relocating it on the first floor of the Fulton Lot building in the space vacated by Department 4 as shown in Drawing 6. This should provide sufficient space to store all rough stock and castings and, further, its ground level location should improve greatly the material handling involved in the receipt and issue of metal stock.

d) Move the shipping room to the first floor of the Fulton Lot building as shown by Drawing 6. This move has no real effect on the shipping department, but is done in conjunction with the move to provide space for Department 4 in the main building.

e) Relocate the machines from the boxmaking room to the third floor of the Fulton Lot building as shown in Drawing 7. The required space is gained by relocating the electrical maintenance shop to the former boxmaking room. With just the moving of the two machines and the installation of sawdust removing equipment all the functions of the boxmaking room can be performed here, thus elimi-

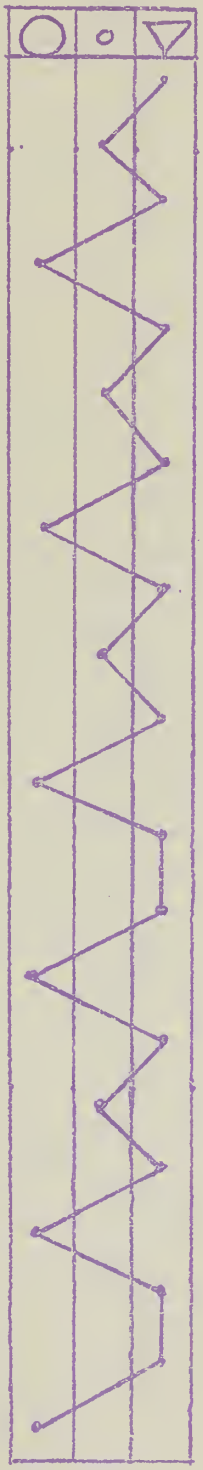
nating considerable handling of lumber and transportations. Boxes and crates needed by the shipping room can be lowered by hand hoist to the shipping room directly below. If management would prefer to relocate the electrical maintenance shop elsewhere, the old boxmaking room could be used for a modern, well-equipped employees' washroom.

The above revised layout could be carried out with a minimum of disruption to plant operations and at a moderate cost. The consolidation of Department 4 should aid supervision greatly, reduce work in-process time and shorten transportations. With the rough stockroom just across the alleyway and on the ground level, materials handling will be simplified greatly for Department 4. These improvements should result in considerable savings in the various manufacturing processes. This plan also makes the Johnson building available for the exclusive use of Departments 7, 8 and 18A, where work in new fields seems to have a bright future and a possible need for expansion.

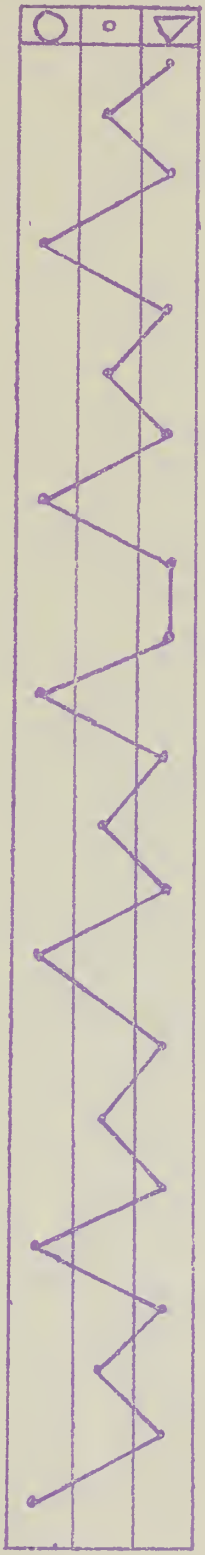
PROCESS FLOW CHART

Tripod Leg: (Stiff leg) Part No. 402

Distance (feet)	Description
	In storage in the kiln
120	Transport to the joiner machine
	Awaiting Operation #1
	Plane two sides on #145
	Awaiting completion of others
12	Transport to the thickness planer
	Awaiting operation #2
	Plane to reg. thickness on #834
	Awaiting completion of others
4	Transport to saw #146
	Awaiting operation #3
	Cut to length on #146
	Awaiting completion of others
	Awaiting operation #4
	Cut to shape-taper on #146
	Awaiting completion of others
40	Transport to drill #138
	Awaiting operation #5
	Drill eye piece hole on #138
	Awaiting completion of others
	Awaiting operation #6
	Drill hand hole on #138



Tripod Leg: (Stiff leg) Part No. 402

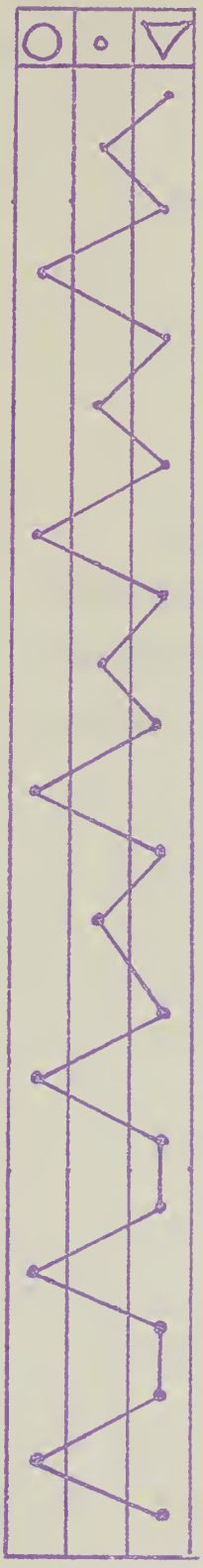


Distance (feet)	Description
	Awaiting completion of others
84	Transport to saw #482
	Awaiting operation #7
	Cut to length on #482
	Awaiting completion of others
40	Transport to shaper #450
	Awaiting operation #8
	Plow out on #450
	Awaiting completion of others
	Awaiting for operation #9
	Bead the edges on #450
	Awaiting completion of others
40	Transport to saw #482
	Awaiting operation #10
	Cut out spline for hand hole on #482
	Awaiting completion of others
40	Transport to shaper #450
	Awaiting operation #11
	Cut for the head on #450
	Awaiting for completion of others
30	Transport to machine #472
	Awaiting operation #12
	Clean out hand hole on #472

Tripod Leg: (Stiff leg) Part No. 402

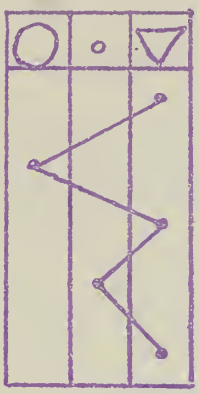
Distance (feet)	Description
	Awaiting completion of others
48	Transport to saw #146
	Awaiting operation #13
	Dado cut (for washer and bolt) on #146
	Awaiting completion of others
4	Transport to shaper #450
	Awaiting operation #14
	Round off head piece on #450
	Awaiting completion of others
	Awaiting operation #14a
	Round off edge on #450
	Awaiting completion of others
52	Transport to joiner #136
	Awaiting operation #15
	Round edge-full length on #136
	Awaiting completion of others
28	Transport to lathe #144
	Awaiting operation #16
	Turn end for point on #144
	Awaiting completion of others
56	Transport to bench
	Awaiting operation #17
	Apply point to leg

Tripod Leg: (Stiff leg) Part No. 402



Distance (feet)	Description
	Awaiting completion of others
8	Transport to drill #510
	Awaiting operation #18
	Drill tripod point on #510
	Awaiting completion of others
8	Transport to the bench
	Awaiting operation #19
	Insert pin-file off by hand
	Awaiting completion of others
24	Transport to sander#148
	Awaiting operation #20
	Sand smooth on #148
	Awaiting completion of others
127	Transport to paint shop on fourth floor
	Awaiting operation #21
	Apply wood filler with a brush
	Awaiting completion of others
	Awaiting operation #22
	Apply shellac
	Awaiting completion of others
	Awaiting operation #23
	Hand sand, lightly
	Awaiting completion of others

Tripod Leg: (Stiff leg) Part No. 02

Distance (feet)		Description
		Awaiting operation #24
		Apply two coats of varnish
		Awaiting completion of others
183		Transport to storage
		In storage.

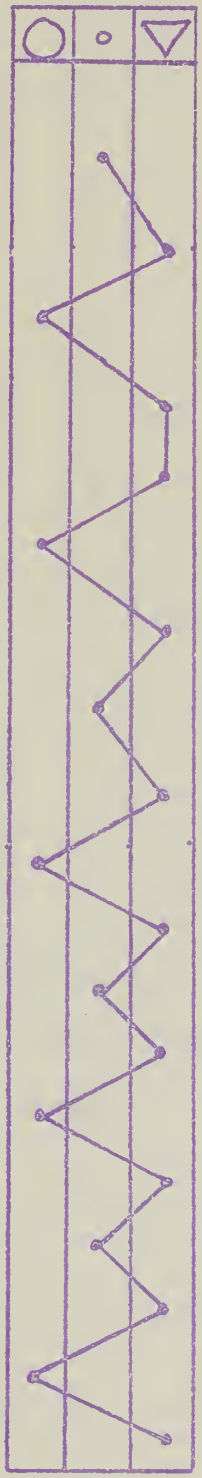
Summary

Operations	11
Transportations	948 ft.
Storages	52

PROCESS FLOW CHART

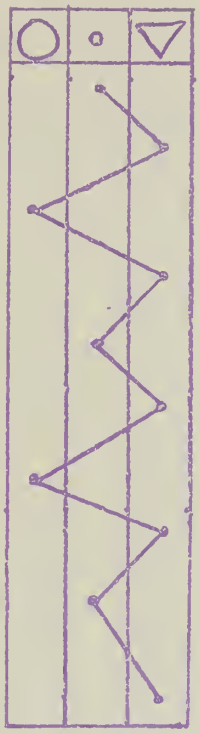
Spindle Part No. 30253

Distance (feet)	Description
	Requisition from stockroom
36	Transport to lathe #446, Fulton Lot Building
	Awaiting operation #1
	Rough turn, face and turn; chamfer center and ream. #446
	Waiting for completion of others
	Awaiting operation #2
	Face, center, rough turn; face and reream center on #446
	Waiting completion of others
140	Transport to Norton Grinder (auto. room)
	Awaiting operation #3
	Grind 2.850 center on #389
	Awaiting completion of others
130	Transport to Fulton Lot
	Awaiting operation #4
	Drill six holes on DP #190
	Awaiting completion of others
309	Transport to Johnson Annex
	Awaiting operation #5
	Grind thread on #679
	Awaiting completion of others



Spindle Part No. 30253

Distance (feet)	Description
48	Transport to lathe #1033
	Awaiting operation #6
	Face shoulder on #1033
	Awaiting completion of others
40	Transport to machine #168 (lathe)
	Awaiting operation #7
	Remove burrs on #168
	Awaiting completion of others
217	Transport to spindle assembly shop
	In storage awaiting assembly

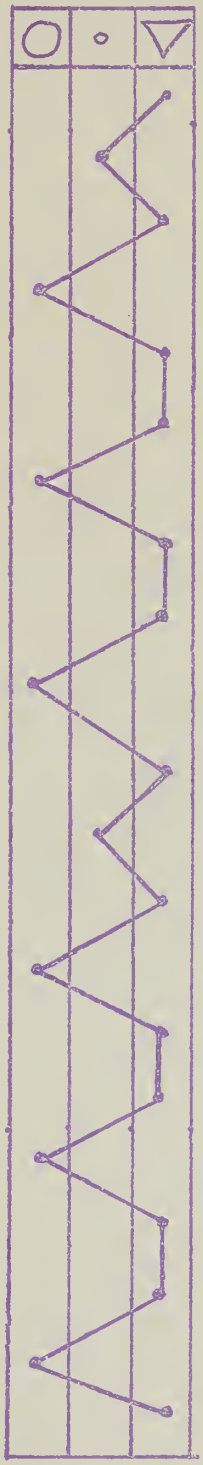


Summary

Operations	7
Transportations	920 ft.
Storages	16

PROCESS FLOW CHART

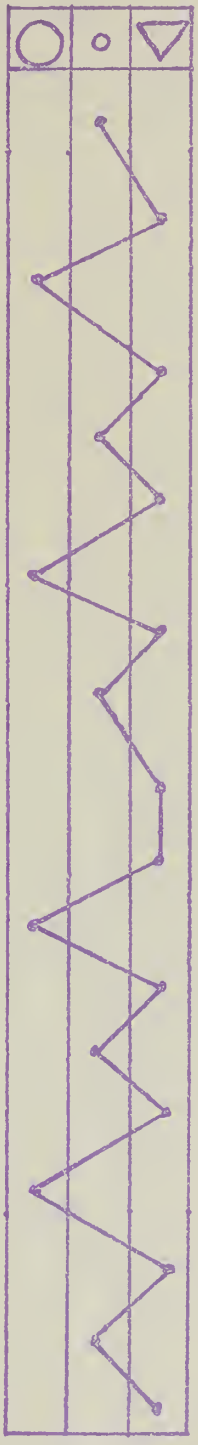
Main Plate (Snap Bezel Type) Part No. 31337



Distance (feet)	Description
	In storage
48	Transport from stockroom
	Awaiting operation #1
	Straighten by hand
	Awaiting completion of others
	Awaiting operation 2
	Face bosses #593
	Awaiting completion of others
	Awaiting operation #3
	Face over all hgt., bore face and form on machine #593
	Awaiting completion of others
28	Transport to drill press #793
	Awaiting operation #4
	Drill holes on machine #793
	Awaiting completion of others
	Awaiting operation #5
	Tap one hole on #763
	Awaiting completion of tapping
	Awaiting operation #6
	Assemble, plug hole by hand
	Awaiting completion of others

Main Plate (Snap Bezel Type) Part No. 31337

Distance (feet)	Description
184	Transport to 2nd floor of Gurley Bldg.
	Awaiting operation #7
	File and burr over plug, on grinder
	Awaiting completion of others
211	Transport to Lacquer Room
	Awaiting operation #8
	Finish #1 inside, #63 face
	Awaiting completion of others
253	Transport to storage (Dividing Room)
	Storage
	Awaiting operation #1
	Engrave as "A" or "B" on #483
	Awaiting completion of others
40	Transport to dividing machine
	Awaiting operation #2
	Divide upcut line (for lining up) on machine #17
	Awaiting completion of others
311	Transport to storage (Fin. Parts)
	In storage.



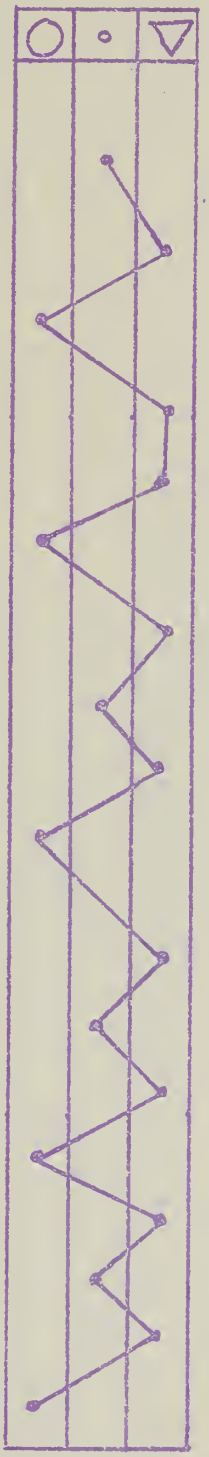
Summary

Operations	11	
Transportations	1075	ft.
Storages	22	

PROCESS FLOW CHART

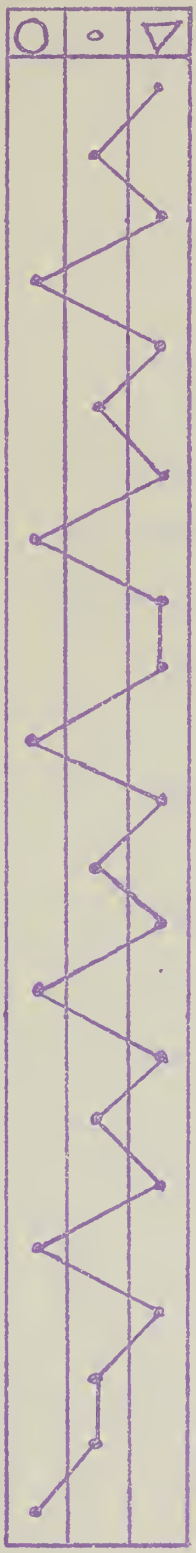
Socket Part No. 30298

Distance (feet)	Description
	Requisition from stockroom
44	Transport to lathe #439, Fulton Lot Bldg.
	Awaiting operation #1
	Turn, face, form, drill, rough ream, finish. #439
	Awaiting completion of others
	Awaiting operation #2
	Face flange, turn taper, face. #439
	Awaiting completion of others
40	Transport to drill pass #190
	Awaiting operation #3
	Drill 6 holes, #190 Drill 4 holes on flange, #190 Spot face 4 holes on flange
	Awaiting completion of others
357	Transport to Johnson Bldg.
	Awaiting operation #4
	Turn, taper, on #425
	Awaiting completion of others
16	Transport to lathe #1033
	Awaiting operation #5
	Face flange. #1033



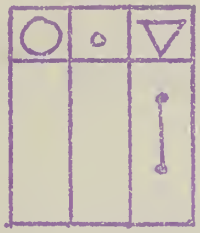
Socket Part No. 30298

Distance (feet)	Description
	Awaiting completion of others
24	Transport to lathe #485
	Awaiting operation #6
	Rough bore. #485
	Awaiting completion of others
24	Transport to lathe #1033
	Awaiting operation #7
	Turn, relief, #1033
	Awaiting completion of others
	Awaiting operation #8
	Turn flange to thk. #1033
	Awaiting completion of others
12	Transport to lathe #512
	Awaiting operation #9
	Cut groove. #512
	Awaiting completion of others
12	Transport to lathe #485
	Awaiting operation #10
	Finish bore. #485
	Awaiting completion of others
24	Transport to lathe #1033
	Awaiting operation #11
	Face both shoulders. #1033



Socket Part No. 30298

Distance (feet)



Description

Awaiting completion of others

In storage awaiting completion of spindle.

Summary

Operations	11
Transportations	553 ft.
Storages	24

PART IV

ENGINEERING AND PLANT MAINTENANCE
(Methods, Standards and Quality Control)

Findings

The personnel presently assigned to the Engineering Department are the Plant Engineer, who is the head of the Department, and his six assistants: an electrical engineer, one chief draftsman, one assistant draftsman, one quality control inspector, one clerk and one general mechanic. The Head of the Department, in addition to being the Plant Engineer, is the Assistant Plant Manager. As the Plant Engineer he reports directly to the President.

The Engineering Department is responsible for the functions enumerated below:

1) Preparation of working drawings and accompanying parts lists.
2) Design, production and storage of tools, jigs and fixtures.
3) Preparation of routing sheets.
4) Methods Engineering and Work Measurement.
5) Quality Control and Inspection.
6) Development projects as assigned by the President. (This has been discussed in the Research and Development Section of this report.)

Preparation of Working Drawings and Accompanying Parts Lists. When a new product has completed the research and development phase and is ready to go into production, the Pilot Model and the master drawings are sent to the Engineering Department. The pilot

model and drawings are studied for a period of time with a view to easing the tolerances and for incorporating changes in design necessary for ease of mass production, utilizing standard interchangeable component parts presently in use in like products wherever possible without affecting the proper functioning and appearance of the product. Upon completion of the study a conference is called between the Optics Research and Development, Design Engineering and Engineering Departments. During this conference the suggested changes are discussed in an informal manner and an agreement is reached as to what changes will be incorporated in the product.

Upon completion of the conference the Plant Engineer schedules:

a) The preparation of a separate drawing for each component part, on which is stated the kind and size of materials required and all dimensions and dimensional tolerances.

b) The preparation of a separate drawing for each component sub-assembly and for the end assembly; each of which accurately and clearly defines the functional relationship of the components involved.

c) The preparation of an accompanying parts list for each component sub-assembly drawing, and for the end assembly drawing which accurately describes and identifies each manufactured and purchased component comprising the assembly.

d) The assignment of identical numbers to parts, drawings, jigs, tools and fixtures.

The Engineering Department maintains an accurate and up-to-

date file by part number of all master working drawings which include any and all changes that have been made on any of the parts. At the present time working drawings for parts are duplicated from the master drawing by the Engineering Department. Upon completion of a given job this working drawing is destroyed and, when the part has to be made again, a new working drawing must be made from the master. The file includes all drawings of past and present products. Drawings are dated from the year 1903 to the present.

The Engineering Department prepares and maintains an accurate parts list. This record itemizes the component parts by number and quantity that make up all of the sub-assembly and end-assembly parts of all the Gurley products. This record is used as a cross-reference for all parts. An additional record is maintained on 3 x 5 cards by part number of all interchangeable components which lists the various components, sub-assemblies and end-assemblies into which the interchangeable item has been incorporated. The information on these 3 x 5 cards is presently being added to the routing sheets in the "sub-assembly section"; at such time as the transposition is complete the 3 x 5 cards will no longer be maintained. These records are used to supply information for repairs, mail orders, inventory difficulties and product information for other departments.

Design, Production and Storage of Tools, Jigs and Fixtures.

At present the tool room has the responsibility of manufacture of the majority of all special tools, jigs and fixtures required for the manufacture of the Company's products. The tool room has the necessary facilities to manufacture any type of device which may be needed by the Production Department.

When a new part is to be manufactured, the Engineering Department forwards all available information concerning the part to the tool room. This information may include drawings and/or models of the part. In general no specific drawings are made for the fabrication of the tool, jig or fixture unless it is very much complicated or out of the ordinary. The majority of the design work on the device is done in the tool room without the benefit of drawings.

When the device is completed, several parts are made from it and they are checked carefully with the drawings for the part to ascertain whether the required tolerances can be maintained. If the tolerances cannot be held by the device, it is reworked until the required tolerances can be maintained. Only then is it ready to be used in the manufacturing process. From the tool room the device is put into the tool crib for issue to the machinist when required.

The tool room is responsible also for grinding, maintenance and repair of the special tools, jigs and fixtures. They also have the responsibility for grinding the milling machine cutters. The part which the tool room plays in the machinery maintenance will be discussed under the maintenance section.

The tool crib is a depository for the devices and gauges used in the Production Department but does not store ordinary drills, bits, files and cutting tools.

After a special tool, jig or fixture is made by the tool room it is put in the tool crib for issue. Each device is given a number which is identical to the part number for which it was fabricated. The devices are stored in the tool crib by a letter number

combination code. A card is made for each device and kept in a master card file. This card shows the part number (which is identical to the device number), the tools and devices used for its manufacture and their location on the shelves by the letter-number combination code. Generally there are several items necessary for the manufacture of the part. All of these tools, jigs and fixtures required for the manufacture of one part are mounted together on a board made especially for proper storage.

The routing sheet for parts to be manufactured lists the necessary devices to be used for manufacture of the part. The devices are drawn from the tool crib by the worker when needed to start the job. A record is kept in a notebook by the attendant in the tool crib of all withdrawals and returns of devices. The worker signs for the device in the notebook. After the need for the device is finished, the worker returns it to the tool crib and his name is crossed off the record book, indicating that the device has been returned. The tool crib attendant checks the device for missing and broken parts before returning it to the storage shelves. This system seems to operate satisfactorily although the tool crib attendant has to run down devices every once in a while to get them returned in time for reissue to other departments or workmen.

Standard size gauges used in the manufacturing process also are kept in the tool crib and are checked out in the same manner as the devices.

The tool crib attendant has the additional duties of doing small production jobs such as deburring screws and the like.

This tool crib is concerned only with the special tools, jigs and fixtures. The other tools, such as drills and standard cutting tools, are kept in the raw material stockroom. They are drawn from the stockroom by the worker with an authorization signed by a foreman. At the present time there is a large surplus of cutting tools, drills and files at each machine, more than enough to handle the workers' needs. In general each worker sharpens his own tools when necessary. This can lead very easily to improper grinding and destruction of the cutting angles on the tools.

Preparation of Routing Sheets. The Engineering Department maintains a complete file of routing sheets for all component parts, sub-assemblies and end-assemblies that have been manufactured, are being manufactured or are to be manufactured in the near future. The Engineering Department is responsible for recording the following information on the Routing Sheet:

1) Part Number
2) Date Routing Sheet Completed
3) Drawing Number
4) Part Name
5) Operation number and department to complete operation with a description of the operation.
6) Machine type and number to perform the operation.
7) Standard set-up time required for each operation, in hours and tenths.
8) Time required to complete 100 pieces
9) Remarks - any pertinent manufacturing instructions not in-

cluded elsewhere.

10) Average run. Number pieces in batch.

11) Material to be used to manufacture part.

12) Code of the material required.

13) Quantity of material required to manufacture 100 pieces.

14) Sub-assembly Parts. In this section are listed all the sub-assemblies and end-assemblies in which the part has been incorporated.

The above routing sheets are completed and distributed to the following people: one copy is kept in the Engineering file; one copy is forwarded to the Accounting Department; one copy is sent to each department foreman assigned to work on the job and filed by him; one copy to the Scheduling Department; and the last copy, which contains the limited information included in Items 1, 2, 4 and 5, goes along with the blueprints and job order. The reason for the limited information on the copy that goes with the job order is that this is all the information required by the worker to complete the job. The other information is used by management for other purposes that are discussed in other sections of this report.

The information recorded on the Route Sheets is obtained from the files maintained in the Engineering Department.

Methods Engineering and Work Measurement. Methods Engineering is the determination of proper sequences of operations for components, sub-assemblies and end-assemblies and in analyzing and standardizing methods for individual operations which conform to specific quality standards.

Work Measurement is the determination of an accurate standard time for each standard manufacturing operation.

The approach to Methods Engineering as performed by the Engineering Department was found to be operating in the following way. For a new product the Plant Engineer calls a conference of all the foremen who will be concerned with the manufacture of the product and at this conference the various operations on each component, sub-assembly and end-assembly are discussed. The method of manufacture of the product is the result of the conference.

For a product that has been produced before, the Chief Draftsman refers to the filed routing card and reproduces it for the new job order.

There is one other approach to Methods Engineering, however, which is the result of a suggestion system. When any member of the Company believes he has determined a method to produce a component, sub-assembly or end-assembly in a more economical manner, he submits it in the form of a suggestion. The suggestion is examined by the Suggestion Committee which is headed by the Plant Engineer. If it is found to be satisfactory, the new method is installed.

The Engineering Department is responsible for setting all standards of performance for the Production Department. There has been no effort made to establish standards by any of the formal means available such as motion analysis, stopwatch time study or operation analysis. This has resulted in the following method of setting time standards. For jobs that have never been performed the Plant Engineer makes an estimate of the time required to complete the job based com-

pletely on experience and data obtained from production of similar items. For items that have been produced previously the Plant Engineer maintains a record of times required to complete the last eight jobs. These job times are averaged and used as the standard time for the jobs.

Quality Control and Inspection Procedures. At W. & L. E. Gurley the management and the employees take great pride in the quality of their products. Quality control is the function of all employees engaged in manufacture and assembly of all products. Procedures are set forth requiring all employees to inspect each component upon completion of manufacture, and further requiring that the foremen make a thorough inspection of the first few pieces completed and subsequent inspections throughout the production run.

The Engineering Department has the responsibility for inspection and quality control for all departments except the reticle, lens and final assembly departments. These departments are responsible for their own inspections and quality control which consists of one hundred percent inspection with records of rejections maintained.

The Engineering Department has one man whose primary responsibility is inspection of finished parts. This inspection does not include inspection of horizontal and vertical limbs, sub-assemblies or final assemblies, which are performed in their respective departments or shops.

The inspection consists of an extremely random sampling process; just a few pieces of each lot are inspected. If during this inspection the sample indicates a variance from the specifications, the entire lot is inspected. In the case of bolts, screws and small parts

they are reworked to make a smaller part; if it is not possible to rework them, they are scrapped. In the case of the larger parts not meeting specifications, the inspector notes any discrepancies on a card before the part goes into the finished stockroom. This discrepancy is cross-referenced to the part that joins the over or undersized part so that the Assembly Department will know that the part does not meet specifications. The majority of inspections are made in the room adjacent to the finished stockroom. Upon completion of the inspection the inspector initials the job order book to indicate that the inspection has been completed. The finished stockroom clerk is instructed not to accept any parts unless the inspector has initialed the job order book. This is an attempt to insure that all parts entering the stockroom meet the specifications as set forth on the drawings and that all discrepancies are noted.

The inspector keeps a record of his inspections in a notebook listing the following data:

1) Date of inspection
2) Part number and name
3) Lot size
4) Any variation from specifications
5) Job order number

The inspector has additional responsibility for:

1) Checking all gauges
2) Testing plating solutions in the plating room
3) Operating the small furnace in the Engineering Department.

Upon completion of assembly all transits, levels and alidades are sent to the collimator test room which is located in the basement of the main building, for a functional test, final adjustment and alignment. This inspection is completed by the Assembly Department personnel which is under the control of the Plant Manager. The instrument then goes into storage to await shipment. If it remains in storage for any length of time, it is given an additional inspection before shipment.

The paper testing machines, permeometers and stiffness testers are compared individually with standards at W. & L. E. Gurley. Testing devices are provided each customer for future testing of the instrument.

Appraisal and Conclusions

General. Under the present organizational structure the Plant Engineer has the additional duty of Assistant Plant Manager and therefore is utilizing a portion of his time in production work which detracts from his primary function as Plant Engineer. In order for an engineering department to function properly it must be free from all productive and development work and it must have its responsibility and authority clearly defined. At W. & L. E. Gurley, however, the Engineering Department is engaged in development and productive work. Under the present system there are no clearly defined statements of any departmental procedures to be followed or any type of job descriptions for any member of the Department. The procedures, responsibilities and authorities seem to have grown from practice and experience.

Preparation of Working Drawings and Accompanying Parts List.

The conference between the Engineering, Research and Development Departments and the Chief Design Draftsman is satisfactory and necessary under the existing procedures. But as stated in the recommendations of the Research and Development Section, this conference can be simplified if the Chief Design Draftsman is required to maintain a file of all standard and interchangeable parts and refers to this file before incorporating any new components into the design of the end product; and the designer must incorporate standard predesigned components into the end-product design whenever it is possible to do so without interfering with the proper functioning of the product.

The present procedure of making a separate drawing for each component part, sub-assembly and end-assembly with accompanying parts lists is a fundamental principle of engineering and should be continued.

The procedure of assigning identical numbers to parts, drawings, tools, jigs and fixtures is an excellent method as it facilitates the locating of drawings, tools, jigs and fixtures whenever it is necessary to do so.

The Department has and is utilizing an adequate system for incorporating changes on and filing master drawings.

The practice of making new working drawings for all job orders is a system that eliminates the possibility of workmen using drawings that have not incorporated the latest revisions. This appears to be a rather expensive program, however. The present costs of reproducing working drawings for each new job should be the subject of an audit to determine whether the costs of screening and filing used working draw-

ings would result in a saving as compared with the present system.

The parts list reference data is complete and proves to be necessary when information is required in reference to any particular sub-assembly or end-assembly.

The changeover of the interchangeable parts list data from 3 x 5 cards to the standard routing sheets is progressing very slowly. Once this changeover is completed it will eliminate one complete file and will make the information available to the departments that have need for it. The interchangeable parts list is located in the Engineering Office and as such anyone needing information from this list must contact the Department by telephone or in person to get it. Under the new system of filing the data on the routing sheets, the information will be available in all departments maintaining a file of routing sheets.

Design, Production and Storage of Tools, Jigs and Fixtures.

Under the present system which requires the tool room to fabricate the majority of the special tools, jigs and fixtures without the aid of drawings there is a complete absence of a methods analysis of the design of the device to be manufactured. Tool room personnel are utilizing a large percentage of their time in design work that should have been accomplished by the design personnel preparing the original drawings of the part, as these personnel are aware of the principles of tool design which will insure maintenance of specified quality standards and achieve minimum operation standard times through reduction of required degrees of operator skill and effort.

The practice of storing machine shop tools, jigs, fixtures

and gauges in different locations throughout the plant is not an efficient practice. From observation it appears that the tool crib and its attendant are not being utilized to their fullest extent. To make use of this idle capacity all tools, jigs, fixtures and gauges required by the Machine Shop with the exception of the permanently issued standard tools should be stored in this centrally located tool crib. This will include the removal of tools and gauges from the raw material stockroom. To initiate this system all tools, jigs, fixtures and gauges should be recalled; inventories should be made; and then the standard tools as required by the machine operators should be issued to them on permanent custody. Those tools retained by the workmen on permanent custody should be returned to the tool crib periodically for inspection and replacement of tools that require grinding. Special tools, jigs, fixtures and gauges as needed to work on a job should be issued on temporary custody and be returned to the tool crib upon completion of the job. Any approved standard form and procedure can be used for this purpose. Examples of various tool crib operating systems and tool issue forms can be located readily in standard texts, e.g., PRODUCTION HANDBOOK by Alford and Bangs, 1950 Edition (Ronald Press) Section 13, page 871.

As noted in the Findings, each workman is grinding his own tools. This practice is contrary to proper tool maintenance and should be discontinued. The tool room has the capacity and the know-how for grinding all tools. This would lead to uniform grinding procedure which would maintain the cutting efficiency of all tools, as any slight variation in the angles of tools will reduce the cutting efficiency to a marked degree. Another reason for tool grinding being done in the

tool room is that it is more economical to issue a sharp set of tools to a workman than to permit him to take time from production work for the purpose of doing his own grinding. Central grinding has the added advantage of increasing tool life six-to-one over operator-ground tools.

Preparation of Routing Sheets. It is evident that in some cases the routing sheets do not show the proper sequence of operations or the correct machines to perform the required operations. The practice of the foreman or worker deciding in which order on which machine to do the operation has developed and they have failed to notify the Engineering Department of the changes. This practice may in some cases simplify the jobs and change the standards maintained in the Engineering Department for the particular job. For good control it is necessary for standards to be as accurate as possible and this requires that any type of change in the sequence or machine used be fully evaluated to determine its desirability or practicality. If the worker or the foreman feels that the sequence is not in the best order, or if different machines could perform the operation more efficiently, this information should be brought to the attention of the Plant Engineer for evaluation before any changes are made. The foreman and the worker probably will not have all the data available as to why the original sequence and machine to be used were decided.

Methods Engineering and Work Measurement. Methods Engineering is the technique that subjects each operation of a given piece of work to close analysis in order to eliminate every unnecessary operation and to approach the quickest and best method of performing each necessary

operation. The best way of doing a specific task is determined by systematic study of the methods, materials, tools and equipment used. After the best way of doing the task is determined, it must be standardized and taught to the operators before any work measurement program is inaugurated.

The basis of all control over productive work is the correct estimate of how long it will take to do a job; the degree of control achieved over the time taken to perform a standard operation is directly dependent on the accuracy with which the standard operation time is determined. The standard time for an operation must be the time required for an average qualified operator working under normal conditions to perform the operation in compliance with the standard operation method, applying normal effort and maintaining specified quality standards without experiencing undue mental or physical fatigue and with due allowances for personal needs.

To insure accuracy and economy of standard operation time determination, standard times must be determined for each element of a standard operation using the most economical appropriate work measurement technique available. Standard times for similar elements of work must be compiled, statistically evaluated and adjusted, and tabulated in the form of standard element time data. Standard operations element times can be ascertained thereafter from the standard data and integrated to accurately and economically determine standard operation time.

The conference method, as stated in the Findings, for determining the sequence of operations and the machines to be used for a new job is not an adequate methods engineering program. This system in no

way determines the proper method of performing each individual operation but rather merely the sequence of operations; also, it is being done by personnel not trained in methods engineering. This conference is the only approach to a methods engineering program and no further work or study is done in this field. To be practical it must be recognized that even if the conference method were adequate, regardless of the amount of methods engineering work which is done in advance, there always will be a vast amount of methods improvement work which it will be profitable to do on existing jobs. Once a job is issued, however, there is never any follow-up or revision done to it unless it is brought to the attention of the Engineering Department that it needs change or revision.

The present method of making an estimate of the time required to complete an operation, and then considering this to be the standard time, is contrary to the fundamental principles of work measurements as stated above. The procedure of using the average of the last eight jobs as standard times are standards set by the workmen and not by the Engineering Department. It must be borne in mind that every job investigated will not require all the refinements that work measurement has to offer. Some classes of work will justify a thorough analysis; others will not warrant such an expenditure of time. The objects of work measurement may be achieved in a number of different ways which are enumerated in MOTION AND TIME STUDY by Ralph Barnes (John Wiley & Sons), Chapter 3, Page 18.

It is concluded that the Engineering Department is not fulfilling its responsibilities of methods engineering and work measure-

ment and that a program should be instituted immediately utilizing the principles as stated in the numerous references on the subjects.

An adequate long-range program cannot be started until there is some determination as to a stabilized level of production. An appraisal of the present utilization and efficiency of machines must be made so that unused and inefficient machines can be scrapped and replaced if necessary by more efficient and economically available ones. Once this has been done a decision has to be made to provide the necessary area that would be required for proper location of machines to result in a minimum of control, materials handling and transportation. Then and only then can a complete and thorough methods engineering and work measurement program be put into effect.

For the present, however, it is believed that W. & L. E. Gurley can make great savings by the initiation of an immediate program which should encompass those operations and processes which would result in the greatest savings, that is to say, those with the longest operations times, most repetitive in nature and greatest investment in capital. A close approximation of this could be obtained by studying those zone "A" items discussed under Inventory Planning and Control.

At the present time there is no program in the Engineering Department or in any other department that weighs the advantages of commercially available items versus production of these items. For example, nuts, bolts, screws and like items. A study of this nature could be made with very little expenditure of time. There are, no doubt, many components presently being used in the end-product that could be purchased for less cost than is required for manufacture by Gurley.

Quality Control and Inspection. If one endeavors to collect the facts as to the cost of quality, he will find that they are widely scattered throughout the organization. Likewise, if one endeavors to collect the facts as to the value of quality, he will again find that they are widely scattered throughout the organization.

This leads to the basic quality problem which is to strike the optimum balance between cost of quality and value of quality for each quality characteristic.

Much confusion arises from the fact that the word "quality" is used indiscriminately for the two widely different meanings, quality of design and quality of conformance. As a rule higher quality of design means higher costs; quite often it also means higher values. Higher quality of conformance generally means lower costs, which means fewer defects be produced at the source, which reduces scrap, rework and sorting. In this way shop costs go down. Moreover, the fewer defects leaving the shops, the fewer there are to go onto the assembly departments.

There is an optimum to quality of design; above this optimum, the increased cost of achieving greater quality of design more than offsets the greater market value of the finished product. Below this optimum the reduction in cost of manufacture is more than offset by a still greater reduction in the value of the product. In like manner there is an optimum to quality of conformance; increased conformance reduces the losses due to defectives. However, the cost of the controls needed for greater conformance rises geometrically as perfection is approached.

Quality control in a dynamic sense is directed at the prevention of defects and unncesssary variability in process factors, rather than primarily at acceptance inspection of parts and products after defects occur. Poor control of the variability of characteristics manufactured must result in high scrap losses, interruption and loss of capacity, costly rework operations and often selective assembly.

The present procedure of requiring the first few components to be inspected and approved by the foreman plus an additional periodic inspection by the foreman and a one hundred percent inspection by the machinist is a good method of achieving quality control if carried on according to plan. It has been observed that many of the machinists are inspecting and gauging all dimensions of each and every part manufactured. This practice is costly and time-consuming and the desired results are not being achieved. This is evidenced by the number of rework job orders and the selective assembly practices.

Inspections, to be adequately performed, should be performed by inspectors acting completely separately and independently of those responsible for the manufacturing processes. This is not being done at W. & L. E. Gurley since the final inspection of the vertical and horizontal limbs, lenses, reticles, finished levels, transits and alidades is being accomplished by their respective departments. However, the one hundred percent inspection performed by the above departments is considered necessary for these components and end-assemblies as any defects in these items would make the final assembly completely rejectable. There are certain types of products that require one hundred

percent inspection and it is felt that these fall within that category. It is concluded therefore that the responsibility for all inspection and quality control be assigned so as to be free of influence by production supervisors and those engineers who prescribe standards. It should be emphasized, however, that assignment of responsibility for quality control to others in no way relieves the production worker and the foreman of their direct responsibility for the quality of goods produced.

No formal system of sampling inspection is in use by the inspector. However, the inspector does select a small sample from every lot for inspection and if defectives are found in the sample, he usually does one hundred percent inspection of the lot. This procedure of acceptance of lots that have samples with no defectives is no assurance that defectives do not exist in the lots. For example, assume a lot of from 25 to 50 parts and a sample size of 5. If there are fifteen percent defectives in the lot, there is a fifty percent chance that the sample will contain no defectives; and if there are thirty-seven percent defectives in the lot once out of every ten times the sample will contain no defectives. In general rather substantially large samples must be inspected to lead to relative assurance that the fraction of defectives of the lot is small. For instance, if the lot were large and a sample of fifty-five were taken and a decision were made to accept the lot as satisfactory, if there are no defectives in the sample, then about once in five times will acceptance be made of a lot that was two percent defective and once in every ten times a lot three percent defective.

The present method of noting over or undersize on parts before entry into the finished stockroom is necessary and money-saving in regard to rework but may not be so as it increases assembly time required to match non-conforming parts during selective assembly.

The records as maintained and the procedures followed by the inspector are not adequate for proper quality control and inspection. An adequate system should include a systematic determination and recording of actual performance as to quality for each operator and piece of equipment. This will aid in seeking to reduce rejected units to an economical level through the medium of modification in the specified standards of quality when the quality standards are found to be unrealistic in terms of machines, tools or operator skills. An evaluation of these records could indicate also when machines are unable to maintain desired standards of performance.

Observations of methods of inspections and record-keeping indicate that there is no follow-up procedure to determine causes and responsibility of defective parts.

The production runs at W. & L. E. Gurley are intermittent and of the small batch types which do not readily lend themselves to quality control by the use of control charts but sampling inspection plans such as Military Standard 105A are adaptable and available in numerous textbooks on statistical quality control. An accepted textbook is STATISTICAL QUALITY CONTROL by Grant. In order to install sampling inspection plans the percent defective of the various lots and the outgoing quality level for the lots must be determined by management.

Recommendations

The following is a summary of the recommendations and proposals which concern the Engineering, Methods, Work Measurement and Quality Control and Inspection functions of W. & L. E. Gurley.

General

1) It is recommended that the Plant Engineer be relieved of the duties as Assistant Plant Manager. This would allow more time for the Engineer to accomplish his basic mission of Engineering.
2) It is proposed that the title of Plant Engineer be changed to one that more adequately describes the function of the Department.
3) It is recommended that the Engineering Department not be assigned production work, this work to be assigned to the Plant Manager.
4) It is recommended that no development projects be assigned to the Engineering Department, all development projects be made the responsibility of the Research and Development Department.
5) It is proposed that job descriptions be prepared in detail for each position in the Engineering Department.

Preparation of Working Drawings and Accompanying Parts Lists

1) It is recommended that the practice of destroying working drawings upon completion of a job be discontinued.
2) It is recommended that the drawings be returned to the Planning and Control Department for filing and subsequent reissue when the part is to be made again. If any changes to the drawing occur, it shall be recalled for destruction by the Engineering Department and a new drawing issued.
3) It is suggested that the changeover of the interchangeable com-

ponent data from 3 x 5 cards to the routing sheets be expedited and the 3 x 5 cards be discarded.

4) It is recommended that the other departments of the organization be notified of the existence of the record of interchangeable parts and be encouraged to use this record when necessary.

Design, Production and Storage of Tools, Jigs, Fixtures.

1) It is recommended that the Engineering Department be held responsible for making and filing drawings of all special tools, jigs and fixtures to be fabricated by the tool room.

2) It is recommended that all tools, jigs, fixtures and gauges required by the Machine Shop be stored in the tool crib with the exception of the permanently issued standard tools.

3) It is recommended that the tools retained by the workmen on permanent custody be returned to the tool crib periodically for inspection and replacement of tools that require grinding.

4) It is recommended that the present tool crib be adapted for the central control point for all tools, jigs, fixtures and gauges for both machine shops as it is conveniently located. In the event the proposed plant layout be accepted, the tool crib to be moved to a central location.

5) It is recommended that all tools be ground in the tool room in order to maintain uniform grinding procedures.

6) It is recommended that an approved tool crib record system be installed for tool control, inventory and evaluation purposes. Evaluation to include usage, tool life, quantity to carry on hand, replacement time cycle and approved vendors.

Preparation of Routing Sheets.

1) It is recommended that all routing sheets be reviewed and brought up to date as to the correct sequence of operations and machines to be used to perform the operations.

2) It is recommended that all workmen be instructed to notify the foreman whenever any change in the sequence of operations is desired.

3) It is recommended that the foremen be instructed to notify the Plant Engineer whenever a change in the sequence or machine is desired so that these changes can be reviewed and incorporated when desireable or practical.

Methods Engineering and Work Measurement.

1) It is recommended that a qualified person be assigned the job of Methods Engineering and Work Measurement as his primary responsibility.

2) It is recommended that management investigate the possibility of instituting a long-range Methods Engineering and Work Measurement program.

3) It is recommended that an immediate Methods Engineering program be started to study those areas where the greatest savings can be realized.

4) It is proposed that a study be made of the present utilization and efficiency of all production machines.

5) It is proposed that a study be made of the feasibility of purchasing commercially available items versus manufacture of those items.

Quality Control and Inspection

1) It is recommended that one person be made responsible for all quality control and inspection and this position be placed as noted in the Organization Chapter, free from the influences of production supervisors and those engineers who prescribe standards.

2) It is suggested that formal sampling plans be investigated for possible use for inspection.

3) It is recommended that the present procedure of foreman and workmen inspection of parts be studied to determine the cause of defective parts reaching the finished stockroom.

4) It is recommended that an approved record system for inspections be installed. Sample records are available in the PRODUCTION HANDBOOK by Alford and Bangs, 1950 Edition, Section 10.

5) It is proposed that the inspector be enrolled in an evening course in quality control at a nearby educational institution at Company expense.

6) It is suggested that a periodic report be submitted to management indicating the costs due to poor quality control.

PLANT MAINTENANCE

Findings

At the present time there is no formal program for maintenance of either the physical plant or of the equipment. The only maintenance or repair work that is done is when a defect is reported or a piece of equipment breaks down.

The maintenance and repair of the physical plant is placed under the cognizance of the foreman of the carpenter shop. These responsibilities include:

a) Operation of the boilers

b) Fire alarm system

c) Supervision of the watchmen

d) Moving furniture and office equipment

e) Housekeeping details

f) Operation of the compressed air system

No work requests are submitted for any type of repair work. If any repair work is needed, the foreman is simply notified by telephone or in person and he uses men from the carpenter shop to accomplish the repair work. Labor and material costs for repairs are charged to each building, not to any specific department. No formal records for maintenance and repair work are kept. The only record in use for plant maintenance and repair work is in an informal notebook record maintained by the foreman in charge of the carpenter shop which indicates what jobs have been completed.

All plumbing maintenance and repair work is done by an outside plumber who is generally at the plant at all times. His only job

is in connection with the plumbing and related fixtures. This practice costs the Company from $300 to $350 per month for labor and materials costs.

The repair of all electrical components, such as wiring, lighting and electric motors is under the cognizance of the electrician. He also has the responsibility for the moving and placement of all machines in the plant. As in the case of plant maintenance no work requests are submitted for any services of the electrician; the only work request is by telephone or in person. All charges for labor and material for any type of repair work or for equipment-moving is charged to the building in which performed; no charges are made to a specific machine or department.

Repairs to operating machines are made by the tool room personnel whenever they have the capabilities to perform the work. If not within their capabilities, the machines are sent out to another concern to have the work accomplished. Requests for this work originate from the individual operators when the machine is not functioning properly. No records are maintained on machines in regard to location, state of repair or present condition, capabilities to perform task for which designed and past history.

The preventive maintenance program consists of a weekly oiling, greasing and cleaning performed by the machine operators. This does not include a functional check to determine whether the machine is operating satisfactorily.

Appraisal and Conclusions

The primary task of maintenance personnel is to keep buildings, service equipment and production machinery in a satisfactory condition for use, according to standards set by management. In order to accomplish this primary task a system of preventive maintenance is necessary to insure that all items of service equipment and production machinery are fully capable of performing the work task for which designed in such a manner so as to promote the greatest economic benefit to the organization. A plant repair program is also necessary to insure that the buildings housing such equipment are kept in a satisfactory condition to protect the equipment and personnel therein. For proper performance of these tasks a central control is necessary so that all information concerning the maintenance program can be systematically collected and evaluated. Sample equipment and facilities records are available in the PRODUCTION HANDBOOK by Alford and Bangs, 1950 Edition. With no system of record-keeping of any maintenance work it is virtually impossible to attempt to determine the current condition or previous history of a machine. This information is one factor in determining whether a machine can be economically maintained or should be replaced.

In this company the electrician has the responsibility for electrical maintenance, the carpenter for the physical plant, an outside plumber for the plumbing, and it appears that no one person is directly responsible for the maintenance of the production machinery. This diversity of responsibility for maintenance work does not lead to effective control over the work and the boundaries of responsibility are not clearly defined.

The maintenance does not appear to be extensive enough to warrant a fulltime complement of maintenance personnel by crafts or trades. In view of this a program should be set up to place all maintenance work under one head to correlate the work and that personnel by crafts and trades be made available to him on a call basis.

The present system of using an outside plumber to perform all plumbing maintenance is a satisfactory arrangement as there is not enough work to warrant one on a fulltime basis. However, there seems to be no control exercised over the activities of the plumber, that is, he decides for himself what work shall be done, when it will be accomplished, and how long it takes. He does not report in or out on any job and this could lead to excessive costs for work accomplished. This situation could be remedied by having the head of the maintenance program responsible for the sphere of activity of the plumber.

Recommendations

1) It is recommended that one person be assigned the responsibility for the coordination of all maintenance work.
2) It is recommended that the responsibilities of the head of the maintenance program be stated in writing.
3) It is recommended that sufficient personnel, by crafts and trades, be made available, on a call basis, to the head of the maintenance program to accomplish work that the permanent force cannot perform.
4) It is recommended that a system of work requests be instituted for maintenance work and that no work be performed without a work re-

quest except in emergencies and then it should be followed up with a work request.

5) It is recommended that a system of records be established for each machine and phase of maintenance work. Some examples of record forms are shown in the PRODUCTION HANDBOOK by Alford and Bangs, 1950 Edition.

6) It is recommended that machine maintenance records be evaluated periodically to determine whether it is more economical to maintain the machine or replace it.

7) It is recommended that the head of the maintenance program be responsible for the activities of the plumber.

8) It is recommended that preventive maintenance work be scheduled.

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